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BAYER LEVERKUSEN (GERMANY)

Department for Plant Protection

# Relations Existing between Infestation by Virus Vectors and Virus Propagation in Potato Fields

by

Dr. W. Rönnebeck, Institute for Phytopathology, Justus-Liebig University, Giessen

(Director: Prof. Dr. E. Brandenburg)

This Spring, farmers in the Cologne area were once again full of anxiety as they inspected their potato stocks, just as they have been every year for the past half century. Even as far back as 1904, "serious looking symptoms" appeared on the foliage of the *Magnum bonum* variety which in those days was very popular and widely cultivated. Towards the end of 1905 symptoms of leaf roll were detected on the plants, a disease with which we are most familiar today but which was still unknown at that time. Since then leaf roll has become known to us as an epidemic disease. For fifty years it has been the main degeneration disease and as yet we have never been successful in controlling it effectively. If large quantities of approved seed were not used every year by potato growers, then all our potato stocks would be completely infected with leaf roll within a matter of a few years.

This short paper will, therefore, be confined to the leaf roll disease, in particular to the relations existing between the disease and its vector which, in the main, is the green peach aphid. Naturally this is but one section of the problem of degeneration in potatoes, and an even smaller part of the entire complex of questions appertaining to seed production. Nevertheless this question is of great importance because leaf roll happens to be the major disease among viruses occurring in the fields. Just the same, the facts should not be viewed solely from one aspect. A large number of other factors, e. g. those associated with cultivation conditions, are also responsible for the present situation. These have by no means been overlooked. In spite of this, and considering all that we know today, the virus infection is the *conditio sine qua non*. For this reason it is our intention to deal here with the question as to how the virus spreads in the fields, in what form and at what time of the year.

Therefore, let us first examine the development of the green peach aphid during the course of a vegetation period. Fig. 1 shows juvenile larvae which have just emerged from the winter egg on a peach tree. The larval development of these aphids which are known as "fundatrices", lasts from the time when the buds begin to swell until the blossom appears. In Fig. 2 they are shown in a more advanced larval stage on a flower bud. As an adult insect, the fundatrix immediately deposits living young, the so-called fundatrigeniae, the population of which is illustrated in Fig. 3. These insects require 15 to 17

Fig. 1: Young fundatrices on peach buds.

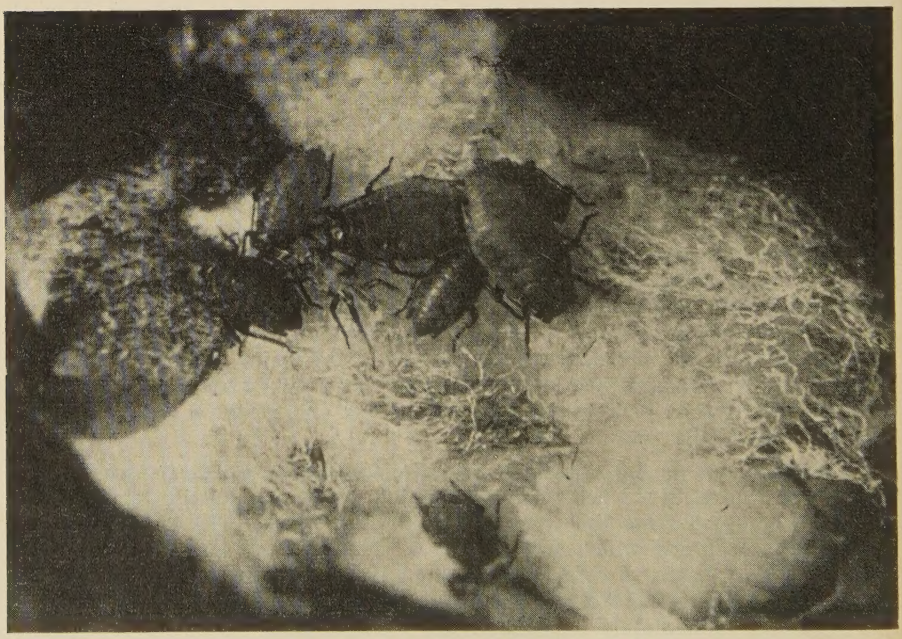


Fig. 2: Older fundatrices on a flower bud of a peach tree.

days for their development dependent upon the temperature, and as soon as they have matured they are also able to bear larvae. As a rule, two or three generations of fundatrigeniae are observed, and the last one develops exclusively into alate aphids. Larvae of those aphids which have wings as fully-grown insects, are recognized from their wing sheaths. Such insects are also called nymphs. Fig. 4 shows nymphs and alate aphids on a peach leaf. All imagoes, like those shown here, can only be recognized close up by means of magnifying glasses (5—15 × magnification). These were made from colour photographs taken by the author.

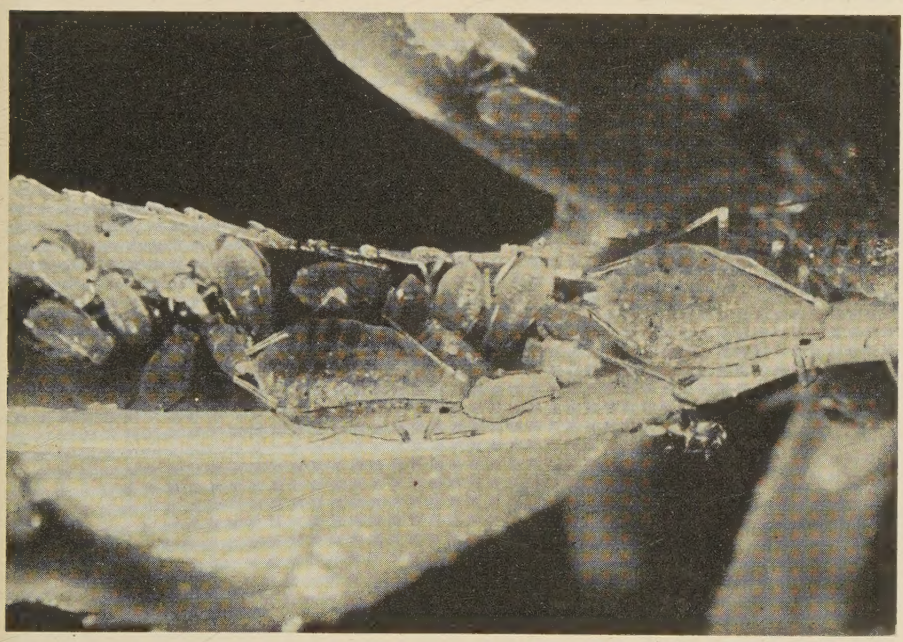


Fig. 3: Population of fundatrigeniae. (The insects one finds in Summer on potatoes, differ very little from these.)

These alate aphids occur in large numbers on winter rye from the shooting stage onwards. They fly from the winter host to the leafy summer hosts so that in this way they reach, among other plants, beets and potatoes. The number of alate aphids reaching a potato field, and in fact even the number of larvae deposited during the first 8 to 12 days, is mostly so small that the insects cannot be found even with the aid of the conventional 100 leaf count. Naturally alate aphids can be found when one knows where to look for them on the plant. For example on April 27, 1954, the author found an alate green peach aphid every two to three minutes in a field of early potatoes which had emerged very timely. This was near Herbstein in Vogelsberg (500 metres a. s. l.). It was established beyond all doubt that these aphids originated from the

peach tree. (This can be recognized from the tube at the rear of the body.) On this particular day the weather was warm and sunny with high pressures, in fact ideal conditions for the flight of aphids. In such weather the alate aphids occurring in Spring can reach any place in our highland regions. If potatoes have already emerged at this time in these areas, they will also be colonized by the migrants. The number of insects reaching these high locations will of course be smaller than the number on the peach trees of areas nearer to, but the number of aphids is not of such great importance as was thought only a few years ago. The most important factor is whether a potato field is reached by the green peach aphid at all. Already knowing this fact, it is not our intention in this paper to enter into details about the importance of the number of aphids but to deal with the different phases of development during the colonization of the potato by the green peach aphid.

When we speak here only of the peach tree as the origin of the alate aphids, then we have our reason. Admittedly alate peach aphids originate in cellars, clamps, pits and greenhouses but it has been shown beyond all doubt that with respect to Rhineland, our own area and Switzerland (as reported in a Swiss paper recently published), by far the greatest percentage (about 90 %) of alate aphids (occurring in Spring) which reach the potatoes originates from peach trees.

The Spring alate aphids deposit living young on the Summer hosts, which grow into wingless aphids in about 14 to 17 days. These form the first generation on potatoes or beets. As soon as the oldest of the insects are fully grown, they in turn immediately begin to deposit larvae which also mature into insects capable of reproduction within a good two weeks. These make up the second generation. In the field, one cannot of course distinguish between the members of the different generations with any degree of certainty, although it can be established which stage of development the oldest insects of the population have reached. One group of the insects in the second generation just mentioned produces alate aphids again and thus begins the Summer flight. The time when this flight begins can, therefore, be predicted with a high degree of certainty! Two generations should normally appear from the beginning of the main flight period (from the peach tree) onwards. Therefore, dependent upon the weather, the Summer flight cannot start until four to five weeks at the earliest after the beginning of the main flight period (shooting of rye). The time when this flight actually starts, and also its strength depend upon the weather and the numbers of aphids colonizing the Summer hosts.

The aphid population generally "collapses" between the middle of July and the middle of August, in other words there is a rapid reduction in the numbers of insects until there are no more present. The reason for this cannot be clearly established in every case but the most important factors responsible are always fungus growth, predators (e. g. ladybirds and their larvae), and parasitizing. In many cases, these rapid reductions are also due to temperatures of over 30 °C which have a very unfavourable effect on the population. The potato stock, however, never becomes completely free from aphids. There is a further reproduction in September on varieties which are still green during this particular month, with the result that towards the end of September alate aphids develop which fly to the peach trees and deposit

larvae there. These larvae then grow into females. Later when they are copulated by the males which follow them to the peach trees, they lay numerous winter eggs chiefly in the axils of the buds. It is from these eggs that the fundatrices again emerge at the end of February and the beginning of March the following year.

During the colonization of potatoes by the main virus vector, *Myzus persicae* Sulzer, there are three periods in which there is a danger of virus transmission. The extent of the danger during these periods may vary due to the fact that the influences on the aphids

Fig. 4: Nymphs and alate aphids on a peach leaf. In between the insects are a large number of skins shed by nymphs during their transformation to alate aphids. On potatoes the insects have the same form.

caused chiefly by the weather change from year to year. The first period includes the two wingless generations which initiate the infestation. Due to the great susceptibility of young plants, it will take relatively few insects to produce a high effect at this time. During the course of their migrations — studies by Czerwinski at the Berlin Institute for Plant Cultivation have shown that on sunny days about 15 % of the insects change their plant hosts — they chiefly transmit leaf roll virus to the neighbouring stocks of secondary diseased plants. In many cases they forestall a selection by doing this — e. g. in 1954 — which means that they have already infected several adjoining shoots when the diseased plant is removed. In Holland, attention is drawn to the fact that when the diseased plant is

removed, aphids may fall off or be knocked off. These aphids then migrate to other plants which they infect. This shows that selection alone is not always an adequate measure. In 1954 it was seldom possible to prevent the first virus transmissions whereas in Spring of 1955 the conditions were exceptionally favourable particularly in Wetterau. Observations I made near Giessen showed that in 1955 the spread of leaf roll virus became stronger in the last 10 days of June whereas this happened 14 days earlier in 1954. The effects on the health of seed potatoes in the Spring of 1956 will be very informative.

The second period begins with the Summer flight of alate peach aphids from their leafy hosts. In fact this period might start 4 to 5 weeks after the colonization of these hosts. The strength of this flight and consequently its significance for the spread of virus depends very largely upon the weather. Cool, rainy weather may restrict the summer flight considerably whereas periods of warm, dry weather may render it great assistance. The considerable importance of this period is due to the fact that now virus may be carried from infected fields to healthy or disinfected fields through the flying activities of the aphids. On the other hand, the wingless aphids already present in the non-infected fields are then able to carry the virus, once brought in, from shoot to shoot and from plant to plant because the activities of the wingless types do not cease as soon as the alate aphids appear.

We have, therefore, become acquainted here with two forms of virus propagation: 1. Propagation of virus by migrating wingless aphids (90 to 95 % of the population), spreading or "fluctuating" in wave form from the secondary diseased plants chiefly in the direction of the rows. 2. The "springing" virus propagation by alate aphids. The proportion of the significance of both forms for the infection of a potato field may differ greatly dependent upon the weather and the rate of aphid reproduction, and upon whether there were many sources of infection present in the stock or whether the stock was more or less healthy. However, it can by no means be said that about 90 % of the infections are caused by alate aphids as a fixed rate, such as stated in the English literature. Of course, this might happen under certain conditions but most certainly not as a rule.

As an example of this, we have the result of an experiment conducted in 1954 in our test field at Giessen. We interspersed 5 % sources of infection in a healthy stock of the *Bona* variety (Fig. 5). These were located next to each other in two neighbouring rows. Once they had fully ripened, we harvested the surrounding "α" plants, then the adjoining "β" plants, and finally the 3 rows of "γ" plants located some distance away. Wherever the infectors had not been removed, we found the following degrees of infestation in the next crop:

| | |
|---|---|
| α plants: | 39 % |
| β plants: | 40 % |
| γ plants: | 9 % |
| No sources of infection in stock: | 2 % |

The great decrease in re-infections following the removal of the sources of infection definitely shows that the wingless aphids spread the virus from these infection sources in a "fluctuating manner". If the virus were propagated by alate aphids, either from the sources of infection or from outside

the test stock, then there could hardly be an increase of infestation in the direction of the infectors because after all the flights cover a certain distance which wingless aphids do not.

We also selected these sources of infection on June 12, June 19 and July 2, in the same manner that it is done in the cultivation of seed potatoes. We were not successful in reducing the infections to any considerable extent.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| γ | 0 | β | β | β | β | 0 | γ |
| γ | 0 | α | α | α | α | 0 | γ |
| γ | 0 | α | (J) | (J) | α | 0 | γ |
| γ | 0 | α | α | α | α | 0 | γ |
| γ | 0 | β | β | β | β | 0 | γ |
| γ | 0 | β | β | β | β | 0 | γ |
| γ | 0 | α | α | α | α | 0 | γ |
| γ | 0 | α | (J) | (J) | α | 0 | γ |
| γ | 0 | α | α | α | α | 0 | γ |
| γ | 0 | β | β | β | β | 0 | γ |

Percentages of plants: J = 5 %, α + β = 45 %, 0 + γ = 50 %

Fig. 5: Test plan, 1954.

| | α plants | β plants | γ plants | |
|---|---|---|---|---|
| Selected on June 12 | 33 | 25 | 13 | % of leaf roll |
| Selected on June 19 | 37 | 25 | 9 | |
| Selected on July 2 | 39 | 32 | 8 | |

Stock emerged on May 31.

Because the selection, as proved here, practically failed in 1954, we regard this as the main reason why the health of the seed potatoes was hardly any better than usual, despite the fact that the Summer flight was so insignificant.

The third danger period of virus transmission is in September and October. This transmission is only of importance for long-lived varieties although even

here it may lead to unpleasant virus propagation in certain cases. Therefore, late varieties should be kept under supervision, or harvested, during this period, too.

From the information given in this paper, it is evident that the measures taken at present are still not adequate to give effective control of leaf roll, an epidemic disease which has now been prevailing for fifty years. It will not be until more advanced measures are taken based on present-day experience and know-how that there will be any prospects of establishing a standard of hygiene in potato fields which will enable us to achieve our aim.

## Sugar Beet Yellows in South Germany, with Particular Reference to Conditions in Rheinhessen/Pfalz

Dr. Ehrhardt Hanf, Research Station, Worms

There is no doubt whatsoever that in addition to the Cologne and Münster districts, which since 1949 have been the two main regions badly plagued by sugar beet yellows, the area around Worms, Frankenthal and Gross-Gerau must also be classified as a region of serious infestation. In this region large-scale infection occurs in the Rhine plain on both banks of the river, spreading in all four directions until it gradually becomes weaker. It was particularly in 1952 and 1953 that early infections occurred in this area followed by total infestation. In 1954, however, the disease did not occur so seriously as in the preceding years due to the cold, wet weather. Just the same an outbreak of the disease must always be anticipated because in this region of little rainfall there are always dry periods which in warm sunny weather stimulate the occurrence of the disease thus creating a danger of serious yield losses of beets and sugar.

Fortunately, however, not all sugar beet growing districts in South Germany as so badly infected by yellows as to warrant a control of the virus vectors, in particular the two aphid species *Doralis fabae* and *Myzodes persicae*. As these areas are far larger than the main region of infestation in which a direct control is essential, mention will be made firstly of measures which might probably prevent further spreading of yellows. Following many years of experience, these measures finally produced good results in Rhineland and Westphalia in the prophylactic control of yellows, and could be applied in South Germany without difficulty.

*Myzodes persicae* does not overwinter only on peach trees in the egg stage. It is a known fact that fodder beet pits also serve as winter quarters for hibernating aphids. In 1954 *Myzodes persicae* was found in fodder beet pits also in Rheinhessen/Pfalz and in Hessen (Ried). Apart from the pits, beet tops left over in beet fields offer good sources of infection for the alate aphids migrating from the peach trees in Spring. It is, therefore, essential that pits are completely cleared in Spring before the aphid flight begins.

It was also established in 1953 and 1954 that in all places where beet seed had been cultivated (e. g. in the districts of Stuttgart—Heilbronn, Odenwald, Remmlingen), the surrounding fields were more heavily infected than those located farther away. Whether a remedy can be found in these localities by keeping beet seed cultivation separate from general beet growing, is something which must be left to local conditions. At all events, the cultivation in fodder beet fields (Odenwald) of fodder beet seed which often amounts to only very little, should be stopped. In fact the profits gained from this cultivation of fodder beet seed is by no means proportional to the damage caused.

In regions with a mild climate (Pfalz, Bergstrasse), the cultivation of winter spinach most probably plays no inconsiderable part in the transmission of virus from one year to another. The earlier the spinach is drilled, the more virus-infected it will become. If spinach or seed bearing plants are then left standing until the Spring flight of aphids begins, the cycle will be completed, quite apart from the fact that in mild winters the aphids also overwinter on spinach in their Summer form and can be the starting-point in Spring for an early occurrence of infectious alate aphids.

Therefore, winter spinach should be drilled late and harvested in good time. Cultivation of seed should be avioded in threatened locations.

Everything which stimulates the early growth of beets and which will lead to dense stocks within a very short time also assists in the prophylactic control of yellows. 80,000 plants per hectare should be the aim of growers in order to produce in the shortest time a densely growing stand. Once the stands are compact, they will no longer, or seldom be colonized by aphids. Very often, however, there are no more than 60,000 to 65,000 plants per hectare in our fields, with gaps between them.

In the infested region of Rheinhessen/Pfalz, the worst symptoms of yellows and the biggest yield decreases have been on soils which are crusted over, silted up and infertile. On light soils in dry areas, it is extremely important to stimulate the growth of young plants sown early in order to have a strong root growth in the soil should damage be inflicted later due to drought.

Fertilization, too, must be planned so as to stimulate growth of young plants. In particular, nitrogen should be applied to sugar beets in a readily soluble form and in large dosages when the plants are sown. Care must, however, be exercised with Chile saltpeter because there is the risk of emergence injuries being caused when high dosages of soda dissolve at the same time as the seed germinates. According to Professor Lüdecke, a dosage of superphosphate (approximately 18 kg $P_2O_5$ per hectare) also has a favourable effect on the growth of young plants.

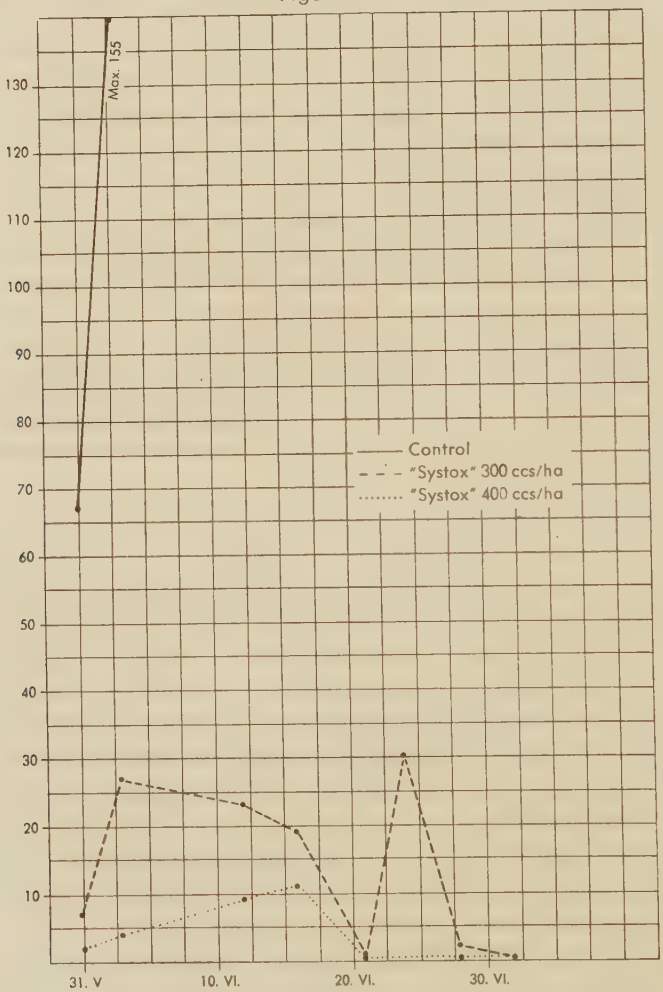
These prophylactic measures, however, are not sufficient in the seriously infected districts in Rheinhessen/Pfalz and in Hessen so that growers have to resort to direct controls of the virus vectors as they have been doing since 1953.

In 1954, approximately 2,000 hectares of sugar beets in Rheinhessen/Pfalz and about 1,000 hectares of the same crop in Hessen were sprayed twice. The technical management of the spraying campaign was in the hands of the local plant protection offices which also supplied the spray equipment. The spraying machines were distributed in such large numbers that under normal conditions one spray ought to have been completed in five days. This time schedule could not be adhered to, however, because rainfall delayed the campaign during both years with the result that it took about eight days to complete one spray.

The area sprayed each day and by each spraying machine depended upon the type that was used and upon the average size of the cultivation area in the different districts. The total average sprayed in 1953 was 7 to 8 hectares per day and per sprayer, with approximately 9 to 10 hectares in 1954.

Only tractors were used for drawing the sprayers. The costs incurred by the farmers were charged to different accounts. In Rheinhessen/Pfalz they were

Figure 1




booked to the "Beet Office" of the Süddeutsche Zucker AG, and in Hessen to the local associations. This procedure will hardly be changed in the coming years since these methods of accounting have become well established in both regions. A subsidy was granted from public funds which amounted to approximately one-third of the total costs.

Dr. Steudel reports that the best time for starting large-scale sprays in Rhineland is when there is an infestation of 0·5 to 1 *Myzodes persicae* per beet. This figure could not be applied in Rheinhessen/Pfalz and in Ried because there were only very small numbers of aphids in the beet fields in 1954. Therefore, it was decided to start spraying as soon as there was a steady increase in the reproduction of *Doralis fabae* and colonies started to form. The success of the sprays shows that this system is quite adequate as a makeshift in years when there is a weak occurrence of *Myzodes persicae*. Future investigations will have to establish whether the weak occurence of *Myzodes persicae* in Hessen and in Rheinhessen/Pfalz applied only to 1954 and was due to the weather conditions prevailing at the time, or whether it will generally be the case, because there are no figures on record for previous years.

The date for the second spray was fixed according to when there was a renewed reproduction of aphids in the check fields and the test fields. Generally it was about a fortnight after the first spray.

Use was made of the experience gained in Rhineland for the selection of suitable control preparations. In consequence, only "Systox" was sprayed at a rate of 400 ccs to 400 litres water per hectare.

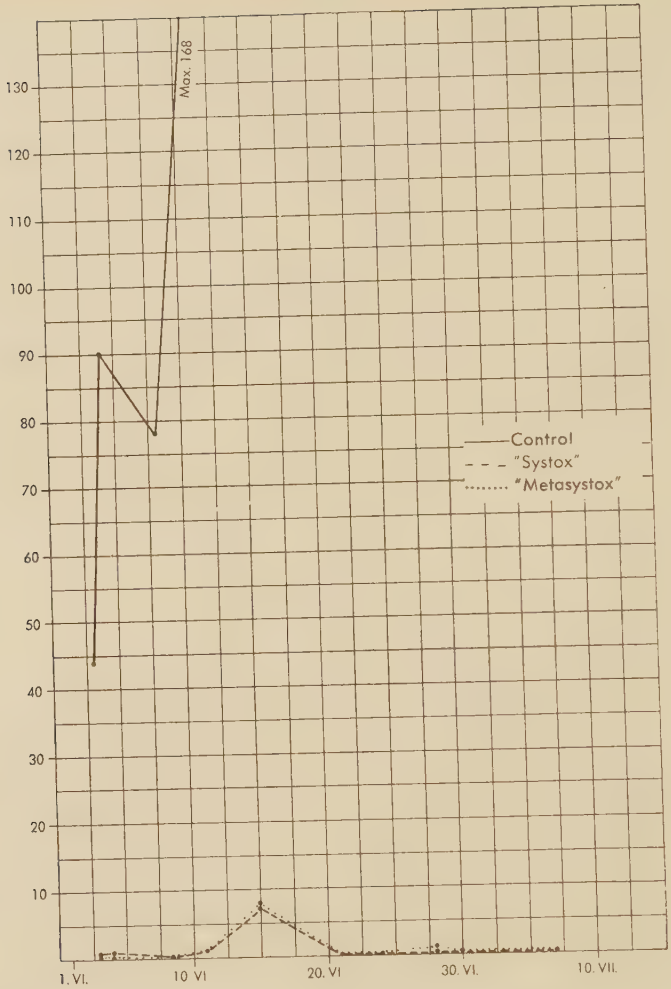
The knock-down results for aphids *(Doralis fabae)* were good. By way of experiment, a spray was applied at the rate of 300 ccs to 300 litres of water per hectare but this did not give a sufficiently high kill. It is essential that 400 ccs of "Systox" active substance are applied per hectare. This conforms with the experience gained in Rhineland (see Fig. 1).

During the course of work carried out in cooperation with the Field Station of the Federal Biological Institute at Elsdorf, the new insecticide "Metasystox" introduced by Farbenfabriken Bayer Aktiengesellschaft, Leverkusen, was compared in 1954 with the established preparation "Systox" in comparison tests of sprays conducted by the Worms Research Station, on the instructions of Dr. Steudel. At a double concentration, i. e. 800 ccs to 400 litres of water per hectare, "Metasystox" produced more or less the same effect as "Systox" applied at the rate of 400 ccs to 400 litres of water per hectare (see Fig. 2). The result was the same as that obtained by the Elsdorf Field Station. On the basis of this experience, it is intended in 1955 only to use "Metasystox" for general spray campaigns. This will make it much easier to carry out and supervise spraying because "Metasystox" is far less toxic than "Systox".

Other groups of active substances compared with the systemic preparations did not come up to the standards of the above-mentioned products of Farbenfabriken Bayer Aktiengesellschaft with respect to instantaneous effects and persistence, so that they will not be used in the large-scale spray campaign of 1955.

In 1955 the area to be sprayed in Hessen will be about the same in the large-scale campaign. The required number of sprayers is available. It will be possible also in 1955 to meet a part of the costs from public funds so that the beet growers will only have to bear about two-thirds. The success of spraying in 1953 was most obvious, because in the untreated fields the beet yields were about 15 to 20 % less than those in the treated fields, with a smaller polarisation amounting to 1·2 to 1·5 % sugar. In 1954 the result was not so pronounced in all districts because as we have already mentioned the disease occurred later than

Figure 2




in the previous years and moreover was not so serious due to the cold wet weather. It is, however, evident from the spray tests conducted that spraying proved to be most profitable also in 1954. The untreated areas showed in all cases a decrease in yield amounting to an average of more than 1500 kg of beets so that the costs of spraying were at least covered in all districts.

A most striking feature was that in 1954 the occurrence of *Myzodes persicae* was very slight in Hessen and in Rheinhessen. Pfalz in comparison with Rhineland. In fact no colonies of *Myzodes persicae* were formed, except in a few fields around Frankenthal. On the other hand, *Doralis fabae* occurred everywhere in large numbers.

Generally speaking, the populations collapsed around June 20th. Renewed colonization and reproduction did not follow. The Autumn flight, too, was very weak. It is presumed that this was due to the weather conditions which were unfavourable for the development and activities of aphids.

Early sowing proved to be most profitable in 1954, too. Late drilled fields had low yields and suffered from more severe and larger numbers of disease symptoms than the early drilled fields. This observation is confirmed by tests conducted for the purpose of establishing the best time for sowing. The areas around Alzey and Mainz were generally more seriously infested in Autumn 1954 than the original area of severe infestation because they had been cultivated late. Southern Pfalz and Western Pfalz continued to remain practically free from infestation of yellows.

## Summary

There is apparently a tendency for sugar beet yellows to spread out even more in South Germany. A distinction must be drawn between areas suffering regular reoccurrences of the disease and where infestation is more or less severe dependent upon the weather, and that region into which the disease infiltrates and which borders on the areas of infestation. In actual fact, the whole of South Germany must be included in the region where the disease is advancing.

At present, direct controls of the virus vectors *(Myzodes persicae* and *Doralis fabae)* are not necessary in the region where the disease is infiltrating. Instead, prophylactic measures must be taken here in an attempt to prevent yellows from spreading any farther.

These measures include:

1. Timely clearance of fodder beet pits.
2. Restriction and regulation of seed cultivation.
3. Regulation of spinach and cabbage cultivation (seed cultivation).
4. Early sowing, with proper treatment of beet stands to ensure adequate density (80,000 plants per hectare).
5. Planning of fertilization to guarantee vigorous growth of young plants so that the stocks will form a dense canopy all the more quickly.

In the main regions of infestation (parts of Rheinhessen/Pfalz around Worms and Frankenthal, parts of Hessen around Gernsheim and Gross-Gerau) it will also be necessary in future to carry out a direct control of the vectors in addition to hygienic and cultural practices.

The spraying campaigns should continue to remain under the strict organisation of the plant protection offices otherwise there will be no guarantee that the controls will be carried out regularly and at the proper times.

"Metasystox", the preparation manufactured by Farbenfabriken Bayer Aktiengesellschaft, Leverkusen, has proved to be the most suitable spray for the large-scale campaigns because tests conducted in Rhineland and in Rheinhessen/Pfalz have shown it to be equal in its effect to "Systox", the preparation previously used. Moreover, it makes the task of spraying much easier, particularly in large-scale controls, because it is far less toxic than "Systox". It must, however, be applied at double the concentration of "Systox", i. e. 800 ccs of "Metasystox" to 400 litres of water per hectare.

# Contribution to the Methods Employed in Carrying Out Tests to Control the Orchard Mite *Paratetranychus pilosus**

by Dr. G. Unterstenhöfer

## Introduction

During the last decade the orchard mite has developed into one of the greatest enemies particularly of large scale fruit growing. As a result of this it has now become absolutely necessary to make the prevention of yield losses caused by this pest the object of extensive research work in the field of pest control. The evaluation of the counter measures, among which chemical control preparations are the most important, is a decisively important aid for evolving the basic principles for such counter measures from a biological and epidemiological aspect. Nowadays this is generally done by taking as the criterion the infestation density on a predetermined number of leaves. The assurance must, however, be given that the infestation density established on this predetermined number of leaves provides a representative and precise example of the average infestation of the treated plot, since it is simply impossible to evaluate all treated leaves — which actually should be checked — growing on all the trees included in the test. In general it should be required that the established infestation density is in direct, causative relationship to the counter measures, and that it is not obliterated by natural and technical causes, the latter resulting from the tests.

In the course of the last 8 years while carrying out extensive biological, epidemiological and technical control studies, consideration has been given to the problem as to which technical test measures should be observed in order to obtain, as far as possible, exact and reliable test results. This problem is, in the main, made up of the following questions which should be given careful consideration:

1. With which number of leaves is it possible to obtain a good average value representing the infestation density? How should the leaf samples be taken?
2. With which number of trees is it possible to obtain a good average value for the infestation density of a plot, and what part is played here by the fruit variety?
3. The marginal and adjacent effect and the possibilities for its elimination.
4. Question of the counting method.
5. Calculation of the numerical values obtained.
6. Is there any possibility, also outdoors, of obtaining an insight into the mode of action with respect to the stage susceptibility?

## 1. Question of the number of leaves and sampling

On scrutinizing the literature published on spider mite control tests, it will be found that the number of leaves examined in the evaluation fluctuates so that it is most difficult to decide which number should be taken.

* Submitted for print in February 1954

Austin and Massee (1) in their investigations established the infestation density on 64 leaves — 16 from each of 4 trees in one plot — and emphasized that this leaf number might be regarded as adequate. The leaf samples were all taken at a height of 1 to 1·5 m, the same number from the inner and outer branches of each tree. They point out that deviations in the results are determined first and foremost by the number of leaves. Chapman and Lienk (2) evaluated 30 leaves (3×10). Underhill (3) ascertained the infestation density on 25 to 50 leaves (1 leaf per cluster per branch). Dean (4) examined 100 leaves per plot — 25 per tree. He took the leaves from various parts around the circumference of the tree at a height of 60 to 180 cm above the ground. In an investigation specially devoted to establishing the infestation density for *Tetranychus pazificus*, Newell (5) arrived at the conclusion that it is necessary to take 56 leaves from half a tree, 100 from 1 to 2 trees and 200 from plots with 5 trees.

The first question which, in view of these obscurities, had to be posed with respect to the minimum number of leaves to be examined, was as follows: Is it at all possible to quote a minimum number of leaves with which, generally speaking, a sufficiently exact value can be ascertained for the average infestation of mites, or does this figure have to be established from case to case? If so, upon what circumstances is it dependent? Fundamentally, the minimum number of leaves to be examined decreases with the uniformity of the infestation. If the degree of infestation on all leaves were the same, it would be quite sufficient to carry out the evaluation on one leaf. Therefore, the more disproportionate the infestation, the larger must be the number of leaves if the casual differences incurred when the samples are taken are to be eliminated. The investigations showed that at the beginning of the vegetation period when the larvae emerge from the winter eggs, the infestation is most disproportionate only to become more and more uniform during the course of the vegetation period. The reason for this is that the female mites continually strive to find fresh, non-infected leaves on which to lay their summer eggs, and consequently to spread the infestation from the base of the shoots up to the tips. The result is that the infestation becomes more and more uniform (6). Proof of this is furnished by an example typical of many counts, namely of the evaluation of infestation density on the same tree during the course of the vegetation period (Table 1).

*Table 1:* Average infestation (eggs and mites) per 10 leaves, evaluated from 50 leaves on untreated and treated trees during vegetation.

| Date | I Untreated checks | | II Preparation S | | III Preparation O | |
|---|---|---|---|---|---|---|
| | A ± m | m % | A ± m | m % | A ± m | m % |
| May 11 | 50·8 ± 14·4 | 28 % | 0 | 0 | 44·0 ± 8·1 | 18 % |
| May 21 | 69·9 ± 12·4 | 18 % | 0 | 0 | 65·6 ± 12·6 | 19 % |
| June 5 | 126·8 ± 19·6 | 15 % | 0 | 0 | 56·6 ± 2·2 | 4 % |
| June 25 | 79·8 ± 10·0 | 13 % | 0·2 ± 0·2 | 100 % | 32·2 ± 12·8 | 38 % |
| July 15 | 484·0 ± 61·5 | 12 % | 1·0 ± 0·8 | 80 % | 21·6 ± 4·6 | 21 % |
| August 13 | 816·6 ± 93·1 | 11 % | 3·8 ± 2·2 | 58 % | 0·8 ± 0·58 | 85 % |

The standard deviation in % of the mean is to be regarded as representing the standard for the uniformity of the infestation. The table shows, with respect to the untreated checks, that the standard deviation in % of the mean decreases more and more during the course of the vegetation period, and consequently the infestation becomes more and more uniform. The values given in columns II and III are also interesting. They show that the standard deviation in % of the mean increases as the effect improves. The weaker the infestation, as the result of a counter measure, the greater are the deviations, which only goes to show how difficult it is to establish the minute differences between preparations having an excellent effect. In this case a very large number of leaves must be taken, particularly at the beginning of the vegetation period, if differences are to be established with any degree of reliability.

In Table 2 information is given in reply to the question what number of leaves should be taken when the spider mites make their first appearance, in other words at a time when the spider mite control is particularly important (7). The infestation density was ascertained on an increasing number of leaves on treated and untreated trees, expressed in infestation per 10 leaves.

The first value (755) given in column I is characteristic of the problem under discussion. It is a typical extreme value such as is continually encountered at the time when the mites begin to hatch around the blossom period. These extreme values resulting from disproportionate infestation — due to hatching at different times as the result of microclimatic conditions (insolation) and disproportionate laying of winter eggs (preference for those sides of the tree away from the wind) — are the cause of the large deviations. As may be expected, the deviation is minimized with an increasing number of leaves, since in the same direction there is also a decrease in the influence exerted by casual extreme values upon the size of the average value.

In columns II and III the values are given for infestation density following the application of two acaricides differing in their degree of efficacy. Once again we have the same picture as that given in Table 1, namely that the standard deviation in % of the mean increases with the degree of effectiveness. On the other hand, particularly in the case of a weak infestation due to control measures being taken, the extent of the deviation does not decrease uniformly with an increase in the number of leaves, at least not in the order of magnitude up to 100 leaves. Despite this the same tendency is perceptible in column II as in column I, and also to a lesser degree in

*Table 2:*

| | | Average infestation per 10 lea | | | |
|---|---|---|---|---|---|
| | | 10 | 20 | 30 | 40 |
| Untreated | A ± m | 755 | 500 ± 253 | 394 ± 182 | 340 ± 139 |
| I | m % | | 51 % | 46 % | 41 % |
| Preparation P | A ± m | 45 | 57 ± 12 | 47·6 ± 11·6 | 38 ± 16·1 |
| II | m % | | 21 % | 24 % | 42 % |
| Preparation S | A ± m | 3 | 2·5 ± 0·5 | 2 ± 0·57 | 1·5 ± 0·65 |
| III | m % | | 20 % | 28 % | 43 % |

column III. In these orders of magnitude it is essential to take larger numbers of leaves, which in view of the weaker infestation and the correspondingly smaller amount of work involved for counting, is no difficult matter. At all events it is again apparent even in this case how careful one has to be in the interpretation of test results particularly with respect to evaluation around the blossom period, when making counts with a small number of leaves, and with a high degree of efficacy.

In view of the above findings which are supported by many other data, it will be difficult to arrive at a standard deviation of below 20 % of the mean with respect to measures taken against the first generation. In fact one will normally have to reckon with 20 to 30 %. In agreement with Austin and Massee (1), who are of the opinion that 64 leaves are sufficient, it may be said that under no circumstances should less than 50 leaves be taken, and on the other hand not more than 100 in the check, if the sampling is to be carried out thoroughly.

With respect to the method of sampling — allowance being made for the different rates of development of the first leaves dependent upon the insolation etc. — it is important that leaves of the same age are always taken from around the circumference of the tree at a certain, and always equal height above the ground. In this way it is possible to bring about further decreases in the differences with respect to the infestation density.

## 2. Question of the number of trees and the varieties

It is continually emphasized that the degree of orchard mite infestation varies with the fruit varieties. Despite the fact that there is a very large number of plant hosts available in Germany, it is chiefly plums, damsons and apples which are attacked (6). Recently the orchard mite has gained importance as one of the pests which attack vines. Up to now no mentionable infestation has been established on cherries and pears despite the fact that there have been heavy occurrences of mites on neighbouring damson and apple trees. Andersen (6) points out that the degree of infestation also differs on the different apple varieties. He mentions "James Grieve" and "Early Victoria" as being particularly susceptible. "Zuccalmaglio" is another variety which is also heavily attacked. The differences in infestation density are considerable, proof of which is furnished by the following count made on three varieties growing in one orchard.

| ith counts made on "x" leaves | | | | | |
|---|---|---|---|---|---|
| 50 | 60 | 70 | 80 | 90 | 100 |
| 301 ± 14<br>37·8 % | 297 ± 99<br>31 % | 282 ± 83<br>29 % | 252 ± 73<br>27 % | 252 ± 62<br>24 % | 363 ± 62<br>24 % |
| 35·4 ± 10·2<br>29 % | 32·2 ± 8·8<br>27 % | 31·9 ± 7·6<br>24 % | 30·4 ± 6·6<br>22 % | 33·7 ± 6·7<br>20 % | 36·1 ± 6·4<br>17 % |
| 1·4 ± 0·51<br>36 % | 1·9 ± 0·6<br>31 % | 1·7 ± 0·36<br>21 % | 1·5 ± 0·5<br>23 % | 1·5 ± 0·45<br>30 % | 1·5 ± 0·4<br>27 % |

*Table 3:* Infestation density per 10 leaves on June 5, 1952.

| Variety | Eggs | Post-embryonal stages | Totals |
|---|---|---|---|
| Boskoop | 69 | 48 | 117 |
| Golden Delicious | 65 | 31 | 96 |
| Early Victoria | 1652 | 489 | 2141 |

It should be again pointed out that when determining the infestation density only trees of the same variety can be compared with each other.

In answering the question about the lowest number of trees to be evaluated in one test, very much depends upon whether trees of the same variety in one stand are all infested more or less to the same extent or not. Austin and Massee (1) found in their tests that the infestation on neighbouring trees was very uniform, which indicated that the deviations in the infestation density depend more upon the number of leaves than upon the number of trees. On the basis of our observations, we might, therefore, conclude that this finding should not be regarded as a rule valid for general application. Proof of this is given by the following table, which provides data about the infestation density on two plum trees located relatively close to each other.

*Table 4:* Infestation density (eggs and mites) per 10 leaves in the evaluation of 50 leaves.

| Date | Tree 1 | | Tree 2 | |
|---|---|---|---|---|
| | A ± m | m % | A ± m | m % |
| May 11 | 50·8 ± 14·4 | 28 % | 145·0 ± 29·2 | 20 % |
| May 21 | 69·9 ± 12·4 | 18 % | 249·5 ± 44·3 | 18 % |
| June 5 | 126·8 ± 19·6 | 15 % | 174·0 ± 15·4 | 9·5 % |
| July 15 | 484·0 ± 61·5 | 12 % | 243·0 ± 47·9 | 18 % |
| August 13 | 816·6 ± 93·1 | 11 % | 169· ± 220·8 | 12 % |

With respect to our question it is found that the infestation on trees of the same variety can at least vary to a considerable extent. This means that the evaluation should be carried out on several trees of the same variety and at the same location. Generally the infestation density at the edge of the stand deviates from that of the stand itself.

### 3. Question of the marginal and adjacent effect

The question of the marginal and adjacent effect, considered from the pest standpoint, is directly linked with the active and passive propagation of the mites. Andersen (6) has thoroughly examined this question, and arrived at the conclusion that there is an active propagation within the tree but that this only occurs on neighbouring trees when they are in direct contact with each other. The passive propagation, on the other hand, caused by the wind, is very extensive; with an average wind force of 3 to 4 m per second, 200 to 400 mites were blown onto 1 $m^2$ in an hour. This finding is of great

importance for conducting the tests and evaluating the results because even when steps are taken to prevent the preparation from drifting, there is a passive migration of mites from untreated to treated trees, which are carried by the wind. The smaller the plots and the closer the trees are growing to each other, the greater the treated plots will suffer under the influence of the untreated plots and the greater the degree of effectiveness of a preparation will be concealed due to drifting from treated plots. The tests should, therefore, be arranged so that the drifting of mites is eliminated as far as possible. Normally this is done by dividing the plots into squares, and although they should be treated uniformly only the centres should be evaluated. This is particularly important when the infestation has to be determined for a whole year. With small plots such investigations always lead to completely different results which give either a wrong or at least an unclear picture of the actual situation. Austin and Massee (1) have made allowance for this fact in that from each test plot they selected 24 or 25 trees — 6×4 or 5×5 — and in this way obtained 8 or 9 trees for evaluation which were surrounded by a row of treated trees, with the result that the adjacent effect was to a considerable extent eliminated. In general this method is most commendable if it is intended to obtain a clear reflection of the position. If this is not done, however, it may happen that following a very good effect around the blossom period in autumn, an infestation has to be registered which is well above the value of the check. Due to the fact that the results originate from small plots it often occurs that false opinions are passed with respect to the value of preparations. Such results cannot be regarded as conclusive due to the drifting of the mites.

### 4. Question of the counting method

Because of the smallness of the mites and the necessity to use optical aids when ascertaining the infestation density, on the one hand, and the necessity to carry out the evaluation within a short time, on the other hand, efforts have been made for some time past to work out rapid and reliable methods for carrying out counts.

Austin and Massee (1) developed the so-called imprint recordings. In this method the leaves being examined are placed between two sheets of white paper, and rotated through a hand wringing machine. The eggs and the mites are squashed and leave behind characteristic spots which can be identified on the paper. By means of this method it is possible to take almost as many leaf specimens as possible from numerous plots in one day, and to carry out the counts at a time when there is little other work on hand.

Chapman and Lienk (2) mention a method in which the leaves are gasified in vessels containing ethylene dichloride, and afterwards the dead mites are removed by means of a special brush apparatus and counted.

Newell (5) suggests a method by which the mites are washed off the leaves with a soap solution and then counted.

The method recommended by Austin and Massee can be regarded as being very reliable despite its simplicity.

## 5. Question of the calculation of the numerical values obtained

The data obtained following the evaluation represent absolute numerical values which, however, by no means give an idea of the potency of a measure. At the most they do show whether the infestation density is high or low without, however, indicating whether the obtained values are in any way the result of the control measures or not. Accordingly the relative infestation is of interest, i. e. when one asks what the degree of infestation in the treated plots would have been if no control measures had been carried out. There are various factors on which the established infestation can be based.

In many control measures it is usual to take the proportion "living : dead" as the standard for the effect. In principle this method is worth discussing, also with respect to spider mites. A test result (spray carried out on May 6, evaluation on May 11) would then appear as follows:

*Table 5:*

| | Check | Preparation P | Preparation O | Preparation S |
|---|---|---|---|---|
| Living | 50·8 ± 14·4 | 7·6 ± 1·7 | 44·0 ± 8·1 | 1·0 ± 0·22 |
| Dead | 5·0 ± 3·1 | 18·8 ± 6·5 | 20·8 ± 2·8 | 7·2 ± 1·7 |
| % Knock-down | 9 % | 72 % | 32 % | 88 % |

*Table 6:* The same test evaluated on May 21.

| | Check | Preparation P | Preparation O | Preparation S |
|---|---|---|---|---|
| Living | 69·9 ± 12·4 | 2·0 ± 0·23 | 65·6 ± 12·6 | 0 |
| Dead | 1·4 ± 0·6 | 10·6 ± 3·6 | 11·2 ± 2·8 | 0 |
| % Knock-down | 2 % | 79 % | 17 % | 100 % |

There is, however, one great risk attached to this method insofar as it cannot be absolutely guaranteed that the dead mites will be found.

Another possibility is offered by using the formula of Abbott (7) in which, as is known, the infesation in the check is placed in relation to the infestation in the untreated plots. The above example then gives the following degree of efficacy:

*Table 7:*

| | Preparation P | Preparation O | Preparation S |
|---|---|---|---|
| Degree of efficacy in % on May 11 | 85 % | 13 % | 99 % |
| Degree of efficacy in % on May 21 | 97·4 % | 15·7 % | 100 % |

Sun and Shepard (7) suggest with complete justification another formula which produces a degree of efficacy corrected by the change in population. For the second evaluation on May 21, we thus arrive at the following degree of efficacy:

*Table 8:*

| | Preparation P | Preparation O | Preparation S |
|---|---|---|---|
| Degree of efficacy in % on May 21 | 98 % | 38 % | 100 % |

In cases where the ascertained values are based on the checks (the value established on May 21 is naturally more important than that ascertained on May 11), it is necessary to determine the change in population and to apply the formula of Sun and Shepard. This formula gives the most exact values, although it requires that the infestation in the treated and untreated plots is the same when no treatments are carried out. This, however, can only be recommended with a certain amount of reservation, as already indicated. A greater degree of significance is obtained by determining the infestation in the individual plots before the treatment, placing this in relation to the infestation after the treatment, at the same time making allowance for the change in population. This method cannot, however, be used when preventative measures are taken, unless of course the infestation of winter eggs has been taken beforehand as the starting point, and a check has been made to what extent there is any justification in taking the population density to be the same in both the treated and the untreated plots.

For all that, these considerations show how necessary it is to produce conditions as uniform as possible by careful planning of the tests, otherwise extreme difficulties might be experienced in the interpretation of the numerical values obtained.

## 6. Question of the analysis of the stage-specific effect of acaricides

In order to determine the right dates for applying acaricides it is important to know how susceptible the various stages are to the preparation, in other words to know whether the preparation is effective against summer eggs or post-embryonal stages (active and dormant stages). In the case of the orchard mites, it is expedient only to use summer ovicides when the summer eggs have been laid, while substances having an effect upon post-embryonal stages are applied when the mass of the larvae have emerged from the winter eggs but before summer eggs have been laid. It would take up far too much time to test the preparations together exclusively against summer eggs or post-embryonal stages.

Newell (5) has made a most excellent suggestion how to arrive at differentiated mortality determinations with respect to *Tetranychus pazificus*. For this purpose he makes use of a method evolved on the basis of careful studies made during the various stages of development in relation to the temperature. By means of this method, it is possible to predetermine which stage is reached after a certain time at given temperatures, and vice-versa which stage a mite was passing through at a certain time in the past. A similar

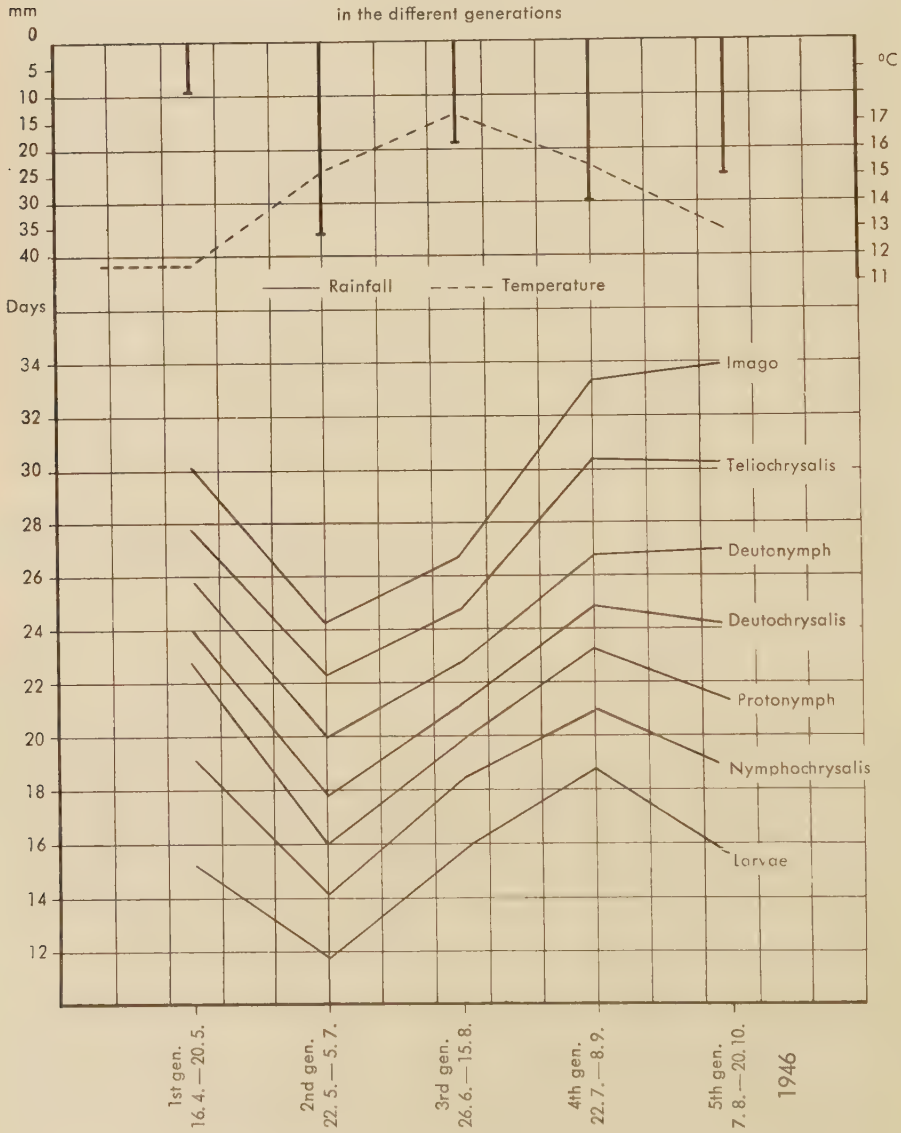
Graph 1

Average period of the embryonal and juvenile development of

**Paratetranychus pilosus**

(only ♀)

in the different generations



method has been discovered for the orchard mite on the basis of studies carried out on the habitus and the life cycle of this particular species (Andersen [6]). Although it is not absolutely reliable, it does provide an approximate picture of the susceptibility of the different stages. Graph 1 furnishes an idea of the average period of development of the different stages in the various generations. The abscissa gives the generations, and the ordinate the number of days. In the first generation for example, the embryonal development lasts 15 days, and 11 days in the second generation etc. For example, if larvae of the first generation are found 16 days following a spray, then this means that they were in the egg stage at the time the spray was applied, and that, therefore, the preparation does not have an ovicidal effect. Such a graph is designed for use in this manner.


## Summary

The technical prerequisites for carrying out spider mite tests are discussed, and the following rules recommended:

1. When determining the infestation density as the criterion for the value of a control measure, the number of leaves to be evaluated is between 50 and 100. The deviations when the mites first occur are greater than later on in the vegetation period. If it is required to determine minute differences between different preparations, a considerably larger number must be taken.
2. The evaluation must be carried out on the same varieties and trees exposed to like conditions at their location.
3. Adjacent effects caused by drifting of the mites must be reduced by using larger plots and only evaluating the centres of these.
4. The evaluation can be simplified by making use of the so-called imprint recordings.
5. The calculation of the numerical values obtained is best done according to the formula of Sun and Shepard.
6. A method for analyzing the mode of action is discussed.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# Control of White Grubs in Standing Cultures

by Dr. L. Rump, Mainz

During recent years, the control of white grubs on agricultural land has been the object of numerous tests and practical trials. The success achieved in this work has been largely responsible for farmers making use of the possibilities offered by white grub control particularly in fields set aside for the cultivation of root crops. By ploughing in soil insecticides based on Lindane either in Autum or early Spring, white grub damage which causes decreased yields can be avoided. Other preparations, too, such as Aldrin, Chlordane, Dieldrin and CBHo are also most commendable for controlling the grubs. A new control method which tests conducted by the Division of Plant Protection for Rhineland-Pfalz showed to be most effective, is the soil application of soil insecticides at the time of the egg-laying flight of the May beetles on fields ploughed before the winter season. The preparation should be harrowed into the top soil to a depth of 7 to 8 cm. The juvenile grubs hatching out of the eggs laid by the May beetles in this top layer of soil very soon come into contact with the preparation when they migrate to their plant hosts, and they are quickly eradicated. In our tests carried out at the time of the May beetle flight in the Spring of 1953, all the grubs had disappeared by late Summer whereas in the checks there were colonies of anything up to 20 grubs in each square metre of ground.

A further method of white grub control which deserves mention is the mechanical eradication of the pests. In tests we carried out over a number of years in cooperation with the Agricultural College at Kandel, several tillage methods were employed which led to the results listed in Table 1. It should be pointed out that in the tests referred to in the table, the results of which fully conform with those of other similar tests, the population of white grubs was established by digging them up before a start was made with the different methods of tillage at the beginning of August 1953, in other words before the first ecdysis of the white grubs. The plots were tilled from August 6 to 28, 1953, in the manner specified in the table, and the work was repeated exactly a fortnight later. All the plots were first turned to a depth of 10 cm although in the repetition of the tillage they were ploughed to a depth of 16 cm. The check diggings were made at the end of September 1953.

*Table 1:*

| Test | Average White Grub population before tillage of the plots | White Grub population following two runs with: | | | |
|---|---|---|---|---|---|
| | | Harrow | Potato digger | Cultivator | Disk harrow |
| Wagner | 9 | 2 | 0 | 0 | 3 |
| Hutmacher | 6 | 3 | 0 | 0 | 1 |
| Hessel | 11 | 5 | 2 | 0 | 8 |
| Zöller | 12 | 1 | 4 | 2 | 9 |
| Haubold | 8 | 1 | 0 | 0 | 2 |
| Average: | 9 | 2·4 | 1·2 | 0·4 | 4·6 |

These test results show that it is definitely possible by using tillage implements to reduce the white grub population to below the critical figure of 3 white grubs per square metre of ground. The unsatisfactory work performed by the disk harrow is due to the fact that this machine lifts the soil between the disks so that the white grubs are not harmed to the same extent as they are by the potato digger and the cultivator. Moreover, the white grubs are not raised out of the ground so that they can be exposed to the effects of the sun.

In our tests, the flooding of meadow-land at the time the May beetles lay their eggs also proved to be an extremely useful method. This practice completely prevented egg-laying in a piece of meadow-land, 200 hectares in area, near Kandel where the damage caused by white grubs in previous years had been so severe that in a year following a May beetle flight very little hay was harvested. It was only in several high parts of the meadow-land which were not flooded, that eggs were laid, resulting in a greater colonization by white grubs. Therefore, this practice can be recommended for preventing damage by white grubs at all places where it is possible to flood meadow-land.

From what has been said above, it is evident that we are today in a position to protect our cultures against injuries by white grubs provided the controls are carried out before the fields are tilled or else, and this point should also be mentioned, provided the humus content of the soil is not too high to prevent the active substances applied from becoming effective, in particular Lindane. It has been proved again und again in our numerous tests that the humus content of the soil, when it is too high, absorbs the active substance so that good knock-down results can no longer be obtained. Nevertheless, treatments of large areas are to be recommended because soils with too high a content of humus are seldom found in districts threatened by attacks of white grubs.

Whereas the problem of white grub controls on untilled fields no longer involves any unsurmountable difficulties, no methods had previously been developed, however, for carrying out an effective white grub control in tilled fields during the course of the vegetation period of cultivated crops. In the past, the farmer has had no option but to put up with the damage inflicted by the white grubs or, if he thought the harvest would be a failure due to the expected damage, he has had to plough up the fields and set a new crop less likely to be attacked by white grubs. The latter emergency measure, however,

is not only a costly practice but generally it is also countered by the difficulty that the presumable damage caused cannot be assessed until it is already too late to recultivate the fields due to the vegetation period having reached a well advanced stage. This is generally the case with root crops, in particular beets, also tobacco, vegetables and cereals, in other words crops which are set relatively late in Spring. Therefore, in order to close a troublesome gap in the control of white grubs, an attempt had to be made to find a suitable method which on the one hand causes no harm to the cultivated plants but on the other hand guarantees eradication of white grubs feeding on plant parts under the soil. The Regional Plant Protection Office of Rhineland-Pfalz was given an excellent opportunity of carrying out tests for this purpose in June 1954, in the beet fields of a farm (Dreihof) located in the district of Landau, which were seriously infested by white grubs. Details of the tests are given below.

The fields at Dreihof are surrounded by large woods which, in the Spring of 1953, were densely populated by May beetles during the unusually big flight of this pest. The treatment of the trees did not meet with the success expected in this district because the May beetles had spread all over the woodland during the course of their feeding activities. Consequently there was a significant migration of May beetles and a serious infestation by white grubs of the land belonging to the Dreihof farm. Even applications of soil insecticides containing Lindane did not help to overcome the white grub calamity due to the high content of humus in the soil. The beet fields, in particular, suffered extremely heavy damage caused by white grub feeding. When the extent of the damage began to develop into a catastrophe at the beginning of June, the main question was not whether the beet fields could be saved by some form of white grub control which needless to say appeared hopeless, but which new crop should be set after the fields had been ploughed. The Regional Plant Protection Office, in agreement with the owners, Herr Staatsminister Stübinger and Herr Landesökonomierat Hauter, availed itself of this opportunity to carry out several tests before the fields were ploughed. The purpose of these tests was to establish whether soil dressings are able to carry the active substance into the soil to a depth of at least 5 cm so that the white grubs in the second stage of development feeding on the roots of the beets will come into contact with the preparation.

The obvious method would have been to dissolve the preparation in water, and to apply the wash over the fields with the liquid manure distributor, a practice often recommended for the control of white grubs on grassland. The Regional Plant Protection Office, however, had never recorded even the slightest degree of success with this method. Moreover, since a minimum of 40 cu. metres of water per hectare would be required (according to information from third parties) to ensure a penetration of the soil to a depth of 5 cm, this practice would mean an inconceivable waste of preparation because the white grubs are to be found on the roots of the beets growing in the rows, and do not occur in the soil between the rows. Moreover, it would be completely impossible and uneconomical for farms the size of Dreihof to transport and apply such huge quantities of water to the fields. Consequently this method had to be dropped from the very outset. Moreover, there was very little prospect of good results being obtained with granular preparations hoed into the ground or washed in by rain. Tests of this description had already been carried out

during the white grub year, 1951, both at the Dreihof farm and at other places with no success whatsoever. Firstly the preparation cannot be hoed in close enough to the roots of the beets, and secondly when washed into the ground by rain, the active substance, Lindane, is absorbed by the humus substances on the surface of the soil so that it does not penetrate through to the white grubs feeding on the roots of the beets.

In view of this, it was decided to use for the tests a power-operated sprayer fitted with two hose couplings and three delivery pipes on each (Fig. 1). 3 metre long spray hoses with guide bars but without spray nozzles were fitted to each

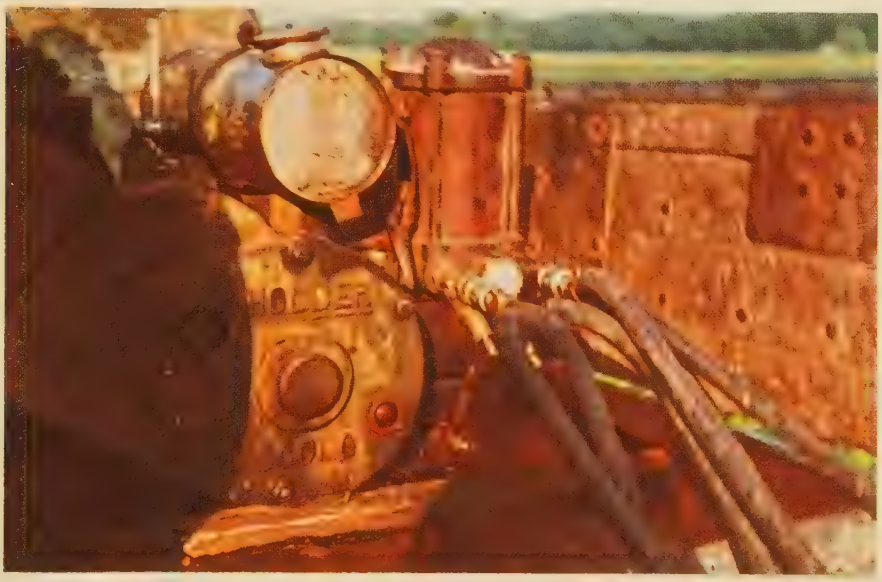


Fig. 1: Arrangement of hoses on the sprayer unit.

of these six delivery pipes. With this arrangement, 3 workers each operating two spray hoses can treat six rows at the same time (Fig. 2). The idea of this equipment is to keep the working hours down to a minimum, in addition to reducing the consumption of water to an economical level. A 0·1 % wash of "Folidol E 605" conc. was used as the soil dressing, and applied at the rate of 1,000 litres per 1/4 hectare. Preliminary tests and applications to control cabbage flies had shown that "Folidol E 605" conc. is not absorbed by the humus substances in the soil but that it is carried deep into the ground by the water in the wash. In view of the very good growth of the beets at the time the tests were conducted, the quantity of wash was increased to 1,500 litres and correspondingly the consumption of "Folidol E 605" conc. per 1/4 hectare as the beets developed. Altogether 50,000 litres of wash and 50 kg of "Folidol E 605" conc. were used over an area of 10 1/4 hectares, i. e. an average of 1,220

Fig. 2: Treating the field.

litres per 1/4 hectare. The tractor driver and three sprayers worked 230 hours to complete the treatment including travelling time, transport of water, cleaning and repairs of the spraying equipment. The working time for each 1/4 hectare of ground was, therefore, approximately 5 1/2 hours, i. e. when four persons were employed, 1/4 hectare was treated in less than 1 1/2 hours. 130 litres of fuel mixture and 6 litres of transmission lubricant were used so that the total costs of the treatment, including wages for the workers but excluding the costs for "Folidol E 605" conc., amounted to DM 25 per 1/4 hectare.

The trial control was started at midday on June 9. The sky was overcast, a moderate westerly wind was blowing, and the temperature was 15 ° C. The area of the beet field was 0·7 hectare (Fig. 3).

The following results were obtained in the counts carried out on the dates given in the table:

| Count on | No. of hours following control | White grubs (2nd stage) | | |
|---|---|---|---|---|
| | | Living | Injured | Dead |
| 10. 6. | 24 | 78 % | 19 % | 3 % |
| 11. 6. | 48 | 49 % | 37 % | 14 % |
| 14. 6. | 120 | 3 % | 17 % | 80 % |

Fig. 3: Field I heavily damaged by white grubs, at the start of the test.

Once these extremely favourable test results had been obtained, it was decided to treat the other sugar beet fields at Dreihof and at a neighbouring farm in Offenbach near Landau (Pfalz), which had all been seriously damaged by white grubs.

A check on the plots, however, soon showed that the knock-down figures are all the lower the later the treatment is carried out.

A test conducted on June 18, 1954, nine days later than the first, produced the results tabulated below. Different concentrations of "Folidol E 605" conc. were used:

| Concentration of « Folidol E 605 » | White grubs counted 3 days after test | | |
|---|---|---|---|
| | Living | Injured | Dead |
| 0·1 % | 33·4 % | 36·6 % | 30 % |
| 0·05 % | 73·4 % | 13·3 % | 13·3 % |
| 0·025 % | 80·0 % | 13·3 % | 6·7 % |

After a further 2 days had elapsed, the test results were somewhat more favourable than those obtained 3 days after the test, but they were not so good as those produced by the test conducted on June 9:

| Concentration of « Folidol E 605 » | White grubs counted 5 days after test | | |
|---|---|---|---|
| | Living | Injured | Dead |
| 0·1 % | 25 % | 15 % | 60 % |
| 0·05 % | 50 % | 25 % | 25 % |
| 0·025 % | 65 % | 20 % | 15 % |

In both the last two tests, all the plots were treated at the rate of 1,250 litres per 1/4 hectare in warm and dry weather.

As shown by the test results, the concentration of "Folidol E 605" conc. should not be reduced below 0·1 % for controlling white grubs in standing cultures because the knock-down figures drop rapidly as the concentration is reduced.

The final test results were established by digging up the ground on September 30 and October 1, 1954. (The figures in the sketches give the number of white grubs found at each point dug up.)

Ground plan for Field 1

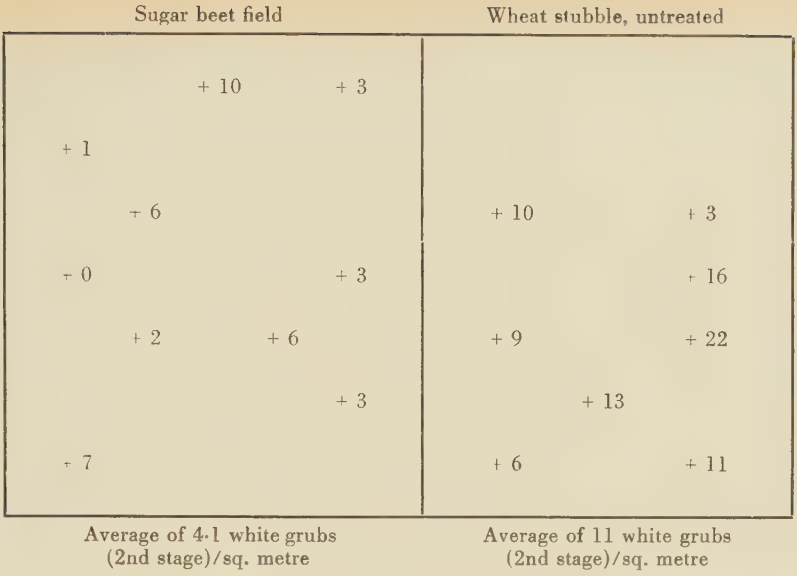
Average of 1·5 white grubs (2nd stage) per sq. metre

*Field I. Sugar beets, treated on June 9 and 10, 1954*

The infestation in this field amounted to 1·5 white grubs (2nd stage) per sq. metre compared with 11·2 per sq. metre before the treatment. The large number of 9 white grubs found close to the barn may be due to the fact that at this point the ground was thickly covered with pieces of straw thus preventing the active substance from reaching the beets and becoming fully effective. The decrease in the number of white grubs by approximately 10 per square metre is most considerable, showing that the standard of the control preparation is quite satisfactory.

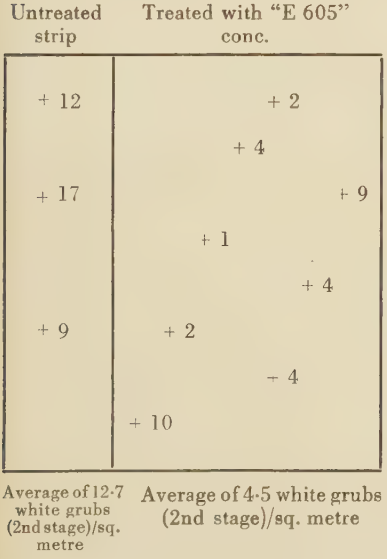
*Field II. Sugar beets, treated on June 15, 1954*

The average infestation in the sugar beet plots was 4·1 white grubs (2nd stage) per square metre. This clearly shows that a treatment delayed by only five days does not produce such good results as an earlier application of the control preparation.




Ground plan for Field II

The fact that a very good effect was nevertheless obtained is shown by the results of the diggings in the plot set with wheat in 1954. The highest figure on October 1, 1954, was 22 white grubs (2nd stage) per sq. metre, and the average infestation was recorded at 11 white grubs per sq. metre.

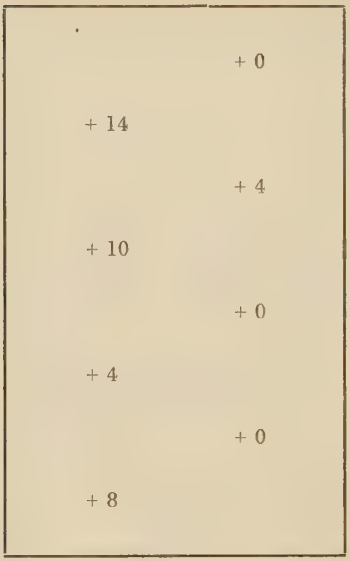



Ground plan for Field III

*Field III. Sugar beets, treated on June 20, 1954*

The treatment of this field, which was delayed by yet a further five days, again resulted in a slight increase of the white grub infestation. The test is of interest, however, for the reason that a comparison with a check strip left untreated shows the application of the control preparation, although much later than in the other cases, to be nevertheless successful even though the white grub infestation is three times as great as in Field I which was treated in good time.

*Field IV. Sugar beets, treated on June 24, 1954*




Average of 5 white grubs (2nd stage)/sq. metre

Ground plan for Field IV

The results of the last test to be conducted are also given. This test, too, demonstrates that a late treatment of the fields leads to a greater white grub infestation. The beets had reached such an advanced stage of development by June 24th, that the rows were already closed up thus making it more difficult to apply the wash to the necks of the beets. In fact, difficulties experienced in applying the "Folidol E 605" conc. wash close to the necks of the beets when the plants are well developed may determine the success of the treatment. In June, the white grubs themselves were always at a depth of only 1 to 3 cm below the soil surface regardless of the development stage of the plants, this being due to the climatic conditions prevailing in the district around Dreihof during this particular month. The fact that the development of the beets at the time of the treatment is not unimportant, is also shown by a comparison of the infestation figures on the left-hand side of the field with those on the right-hand side. On the date the field was treated, the beets on the left-hand side had reached a far more advanced stage of development than those on the right.

A point of interest will be the observations made on the methods employed by the workers treating the field:

Worker No. 1 moved the guide rod along the beet rows at a steady walking pace of 3 km per hour regardless of whether there were large or small gaps in the rows, or whether the plant stock was equally spaced. Consequently "Folidol E 605" conc. wash was unnecessarily wasted at points where the plants had failed to shoot up, in other words places where there were naturally no white grubs in the soil. This was to the disadvantage of plants threatened by white grubs (Fig. 4).

Worker No. 2 moved the guide rod from one healthy plant to another, i. e. plants which obviously were not infested by white grubs, but did not treat either the wilted beets or those plants showing slight symptoms of wilt. After a short period of practice, persons carrying out such work soon learn to recognize quite easily plants attacked by white grubs from the wilt symptoms. By this method of treatment, those plants not yet infested are admittedly afforded better protection because they receive a relatively large dose of "Folidol E 605" conc. However, those white grubs on the attacked plants will not come into contact with the preparation until they migrate to a neighbouring healthy plant.

Worker No. 3 treated both the healthy plants and also the beets apparently already attacked by white grubs, without wasting any wash in the gaps where the plants had failed to shoot up. This method definitely deserves prefer-

Fig. 4: Wrong method of treatment. Gaps in the rows should not be "watered".

ence because the control is directed solely against the white grub which should be brought into contact with "Folidol E 605" conc. no matter where it is at the time of the treatment.

The correct method of treatment is to direct the jet onto the heart of the beet so that the wash spreads evenly around the beet plant and rapidly penetrates into the soil (Fig. 5). Within a short time the workers become expert at directing the jet from plant to plant without wasting any really large quantities of wash in the spaces between the plants or in gaps where the plants have failed to shoot up.

A total of 12·5 hectares of sugar beet fields were treated with "Folidol E 605" conc. between June 9 and 24, 1954, at Dreihof and Offenbach, by means of the soil watering technique. It was established that almost immediately after the fields had been treated, the white grub attacks ceased and the beets began to grow normally. The success of the treatment was also reflected in the harvest yield of 70 to 80 %, which after all was reaped on fields destined to be ploughed in June. There were, of course, still many beets showing traces of attacks by white grubs but these injuries had doubtlessly been inflicted on the young beets prior to the treatment because hardly any traces of fresh attacks were found.

In summarizing, it may be said that by employing the soil watering technique described above and by applying the control preparation as early as possible, satisfactory harvests can be reaped even in the most seriously threatened beet fields. The later the treatment is carried out, the poorer will be the results. To farmers, this means that they should establish the actual extent of the white grub infestation as soon as they detect the first symptoms of wilt

Fig. 5: Correct method of watering. Treatment of individual plants.

on the young beets. This is done by digging up the ground at different points equally spaced all over the beet field. If the white grub infestation has exceeded an average of three white grubs per square metre, the critical figure for beets, then the beets must be thinned immediately if this has not already been done, and "watered" with 0·1 % "Folidol E 605" conc. at the rate of 1,000 litres of wash per 1/4 hectare. The costs are most certainly not too high, and definitely worthwhile. If the fields were to be ploughed and sown with new seed, the costs would be considerably higher.

A c k n o w l e d g e m e n t. Thanks are due to Herr Staatsminister S t ü - b i n g e r and Herr Landesökonomierat H a u t e r for accepting the risk of having the tests conducted on all their beet fields, and for the extremely valuable support they gave.

The experience gained from these large-scale tests in respect of the control of white grubs in standing field crops should prove to be of great value to agricultural circles in areas threatened by white grub infestation.

# Experiments on House Sparrows *(Passer domesticus)* with two Repellents, "Morkit"*) and "Morkit" conc. (VO 4279)

by Dr. Wilfried Przygodda

The many methods employed for preventing damage sparrows cause to crops, aim chiefly at controlling the pest itself. They include the setting of traps, shooting down birds, clearance of nests, and the broadcasting of poisoned wheat grains. However, as these measures do not guarantee immediate protection to endangered cultures, other possibilities have had to be considered, such as the application of repellents. Tests were carried out with "Morkit" and "VO 4279" (now sold under the trade-name of "Morkit" conc.), the repellents manufactured by Farbenfabriken Bayer Aktiengesellschaft, Leverkusen. I started conducting outdoor and laboratory experiments on house sparrows *(Passer domesticus)* in 1951 ** at the Plant Protection Office, Bonn. The manufacturers kindly supplied me with the preparations I required for these experiments. "Morkit" has now been in use for some considerable time as a repellent against rooks *(Corvus frugilegus)* to prevent them attacking grain seed.

The success of such tests naturally depends upon the birds actually having a sense of taste. Botezat (1904) was the first to prove that birds have typical taste buds. According to Stresemann (1927—1934), these buds are never located in the region of the free tongue but are to be found only on the smooth, unhorny mucous membrane of the oral cavity in the vicinity of mucous gland orifices. Bath (1906, quoted in Stresemann 1927—1934) found them on *Passer* and other species in the mucous membrane on both sides of the tongue, which lines the base of the beak chamber. The sense of taste of these birds is, therefore, located in the front part of the beak. Investigations carried out by Rensch (1925) and by Rensch and Neunzig (1925) have shown that the birds have the same four taste qualities as human beings, namely "salty", "sour", "bitter" and "sweet". Even the lower stimulus threshold is about the same. However, most birds, particularly those which feed on grain but also those which eat insects, are hyposensitive to the quality "bitter". Rensch and Neunzig attribute this to the fact that seeds contain bitter constituents and insects frequently contain bitter and sharp secretions so that the birds become accustomed to this. The degree of taste sensitivity is not dependent solely upon the number of taste buds or the number of sensory cells per bud but instead it has been shown by investigations which Engelmann (1950) carried out that there is a simple correlation between both. The number of taste buds must be multiplied by the number of sensory cells. Young birds possess more taste buds than old ones because their tongues are not yet horny. Botezat (quoted by Engelmann 1950) found taste buds both on the tips and the backs of the tongues of young birds. These particular parts become horny when the birds reach the adult stage, and are free from sensory cells. Such changes are mostly completed by the time puberty is reached.

* Reg. Trade Mark, "Bayer" Leverkusen.

** The experiments were financed by the Ministry of Food, Agriculture and Forestry, North-Rhine/Westphalia.

In consequence of this there are favourable prospects for repelling sparrows by using denaturants because the summer swarms of sparrows consist chiefly of impuberal birds.

## Field tests

It is extremely difficult to obtain good results in field tests when dealing with such mobile objects as birds. It does not necessarily mean that the sudden absence of sparrow swarms following the application of a repellent is due to the success of the preparation. The cause of this may often be that the birds have found more plentiful and more appetizing sources of nutrition. Therefore, the evaluation of field tests must be viewed very critically. It is only by carrying out a large number of such tests that a clear opinion can be expressed on the effectiveness of the preparation, or alternatively the conditions at the time must be most favourable. Quite often it is not until laboratory tests are carried out on birds each in separate cages, in support of the field tests, that a definite opinion can be given as to whether the repellent in question is effective or not.

I carried out several field tests with "Morkit" conc. A ripe barley field already damaged to 50 % by sparrows was dusted with this preparation on a warm, clear day at the rate of 25 kg/hectare. A swarm of 50—100 house sparrows appeared from out of the trees of a neighbouring cemetery, and flew over the field immediately after it had been dusted but did not make any serious attacks on the crop. Instead they flew up again after briefly brushing the barley. The sparrows continued to fly backwards and forwards without settling on the barley. After 10 minutes, several sparrows came down until in the end the entire swarm was firmly settled among the barley plants and started to eat the grains from the ears. I had the impression that the sparrows did not like the "Morkit" dust still present in the air. On the following days it was noticed that the sparrow swarm did not return to the field.

The Institute for Agricultural Botany of Bonn University has an area of land for experimental purposes on the outskirts of Bonn. On this land, attacks by house sparrows represent a serious threat to the breeding of the many different species and varieties of cereals grown there. Dr. W e i l i n g , a member of the Institute, supervised a number of tests with "Morkit" conc. (20 kg/hectare) carried out on this land, and I would at this stage express my gratitude to him for this work. The green corn was freshly dusted after each fall of rain. It was found that the sparrows did not eat much of the grain immediately after the plants had been dusted, although the feeding activities suddenly started again on a very large scale after each fall of rain. It was only by repeating the dusting that a stop could be put to these feeding activities until the next fall of rain. One plot of wheat which had not been dusted was, in contrast to the treated plots, completely plundered.

Another test carried out at a different location produced similar results. W e n k e l (1951) also reports on the successful application of "Morkit" and "Morkit" conc. against sparrows.

## Laboratory tests

All the test sparrows *(Passer domesticus)* were caught by means of Schwing's traps, and each was placed in a cage of its own. Certain difficulties were experienced in keeping the sparrows because in the end a large number of them died. Apart from the susceptibility of the young sparrows — and all the birds used in the tests were young — psychological factors also appear to

play an important part. Nevertheless sufficient house sparrows remained alive for the investigation to be carried out and for a satisfactory evaluation to be obtained.

The first preliminary tests were carried out on 12 house sparrows each in a cage of its own. The sparrows were given a certain percentage of wheat ears or wheat grains treated with "Morkit" conc. (15, 20 and 30 kg/hectare), and also a percentage of untreated fodder. The tests were varied in that treated fodder was placed in the left hand corner of the cage and untreated fodder in the other corner while on the other hand equal portions of treated and untreated wheat grains were given to the birds in one food dish. The untreated wheat grains were marked for identification purposes by pricking them with a needle. No preference was shown for the untreated food and in fact the birds continued to feed in a normal manner. These findings would

| Sparrow No. | 100g/50kg M | U | 200g/50kg M |
|---|---|---|---|
| 2 | 6·5 | 7·5 | 7·5 |
| 3 | 5·5 | 7 | 5·5 |
| 4 | 6·5 | 5 | 7·5 |
| 5 | 4·5 | 6·5 | 6·5 |
| Total | 23 | 26 | 27 |
| Average value | 6 | 6·5 | 7 |

*Table 1:*
Wheat grains consumed in g with an initial value of 10 g.
M = Grains treated with "Morkit"
U = Untreated grains

suggest that the preparation was ineffective. Each sparrow, however, had not been given any more than 5 g of grains per day. Consequently it could merely be concluded from these results that the repellent effect of the preparation on house sparrows is either completely inadequate or always too weak to stop hungry sparrows from eating the denatured fodder. On the average, one caged house sparrow consumes 4·5—6 g of ripe dried wheat grains per day according to Mansfeld (1950), whereas my own test showed that 6 g are consumed per day.

The question as to the effectiveness of "Morkit" and "Morkit" conc. on house sparrows still remained unanswered, and in order to clarify this I included a further 15 house sparrows in this test, each kept in a cage of its own. The experiment was divided into three groups.

*Group 1: (cf. Tables 1 and 2)*

Sparrows 2—5 (Table 1) were given wheat grains treated with "Morkit", and sparrows 1, 6 and 7 (Table 2) received wheat grains treated with "Morkit" conc. The experiment lasted more than 3 days. The grains given to the birds

| Sparrow No. | 100g/50kg VO | U | 200g/50kg VO |
|---|---|---|---|
| 1 | 5·5 | 6 | 6 |
| 6 | 4·5 | 5 | 5 |
| 7 | 5·5 | 5·5 | 6 |
| Total | 15·5 | 16·5 | 17 |
| Average value | 5 | 5·5 | 5·5 |

*Table 2:*

Wheat grains consumed in g with an initial value of 10 g.

VO = Grains treated with "Morkit" conc. (VO 4279)

U = Untreated grains

on the first day were treated at a rate of 100 g/50 kg (100 g of preparation to 50 kg of wheat grains), while those given on the third day were treated at a rate of 200 g/50 kg. On the second day the birds were given only untreated wheat grains. Each sparrow received 10 g of treated and untreated wheat grains respectively each day. The grains which were not consumed were gathered the next morning by means of a pair of tweezers and reweighed. In this way it was possible to establish with certainty what quantity had been consumed each day. It was found that the house sparrows, when placed under such pressure, consumed also from the treated (and more heavily dosed) wheat

*Table 3:* Quantity of wheat grains

| Sparrow No. | U | 100 g/50 kg 1st day M | 1st day T | 2nd day M | 2nd day T | 3rd day M | 3rd day T | U | 1st da M |
|---|---|---|---|---|---|---|---|---|---|
| 9 | 9 | 4 | 2·5 | 3·5 | 4 | 2·5 | 2·5 | 9 | 1 |
| 10 | 5 | 1 | 3 | 1 | 5 | 0 | 6 | 6 | 0 |
| 11 | 4·5 | 3 | 0 | 6 | 0 | 6 | 0·5 | 6·5 | 3 |
| 12 | 6·5 | 1 | 3·5 | 0 | 6 | 0·5 | 5 | 6·5 | 0 |
| Total | 25 | 9 | 9 | 10·5 | 15 | 9 | 14 | 28 | 4 |
| Average value | 6·5 | 2·5 | 2·5 | 2·5 | 4 | 2·5 | 3·5 | 7 | 1 |

M = Wheat treated with "Morkit" T = Wheat tr

as many grains as were necessary to cover their daily requirements of food. Consequently there were hardly any differences between the quantities of treated and untreated wheat grains consumed. In fact no differences were observed with respect to the two preparations.

*Group 2 (cf. Tables 3 and 4)*

Completely different results were obtained in the tests when the birds were given 10 g of untreated wheat grains in addition to the 10 g of treated grains. In order to eliminate the possibility of the sparrows detecting a difference in colour, the untreated grains were covered with talc in the same dosage as the treated grains. Each dosage (100 g, 200 g and for sparrow No. 11 300 g/50 kg) was given on three successive days. Before each change in the dosage, one day was left free to give the birds untreated wheat grains. Each sparrow was given two fodder dishes, one containing 10 g of wheat grains treated either with "Morkit" or with "Morkit" conc., and the other containing 10 g of untreated wheat grains. The dish containing the treated wheat grains was put in the same place where the dish containing the untreated fodder had been before the start of the actual denaturation test. The second dish containing the 10 g of untreated grains was placed in the opposite corner of the cage. This was done in order to avoid any possibility of the birds becoming trained. Tables 3 and 4 very distinctly show the increasing efficacy of the repellents — especially in higher dosages — in preventing birds from feeding. Even in this case the individual differences between each of the sparrows became most evident. Sparrow No. 11 in fact consumed more of the wheat grains treated with "Morkit" (dosage of 100 g/50 kg) than from the indifferent talc covered wheat grains. Even an increase in the dosage to 200 g/50 kg did not stop this sparrow from consuming still more of the "Morkit"-treated wheat

umed by the test sparrows

| 200 g/50 kg | | | | U | 300 g/50 kg | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2nd day | | 3rd day | | | 1st day | | 2nd day | | 3rd day | |
| | T | M | T | | M | T | M | T | M | T |
| | 6 | 0·5 | 7 | | | | | | | |
| | 5 | 0 | 5 | | | | | | | |
| | 4·5 | 1·5 | 4 | 5 | 0 | 6 | 0 | 5 | 0 | 5 |
| | 5 | 0 | 4·5 | | | | | | | |
| | 20·5 | 2 | 20·5 | | | | | | | |
| ·5 | 5 | 0·5 | 5 | | | | | | | |

with talc U = Wheat not denaturated

*Table 4:* Quantity of wheat grains in g consumed by the test sparrows

| Sparrow No. | U | 100 g/50 kg | | | | | | U | 200 g 50 kg | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st day | | 2nd day | | 3rd day | | | 1st day | | 2nd day | | 3rd day | |
| | | VO | T | VO | T | VO | T | | VO | T | VO | T | VO | T |
| 13 | 3 | 0·5 | 4 | 0 | 7 | 0 | 6·5 | 5·5 | 0 | 7·5 | 0 | 5·5 | 0 | 5 |
| 14 | 5 | 0 | 5 | 0 | 7 | 0 | 6·5 | 6·5 | 0 | 7·5 | 0 | 4 | 0 | 4 |
| 15 | 6 | 1 | 3·5 | 0 | 6 | 0 | 6·5 | 6·5 | 0 | 7·5 | 0 | 5 | 0 | 5·5 |
| 16 | 6 | 0 | 4 | 0 | 7·5 | 0 | 7 | 6 | 0 | 8·5 | 0 | 7 | 0 | 5 |
| Total | 20 | 1·5 | 16·5 | 0 | 27·5 | 0 | 26·5 | 24·5 | 0 | 31 | 0 | 21·5 | 0 | 19·5 |
| Average value | 5 | 0·5 | 4 | 0 | 7 | 0 | 6 | 6 | 0 | 8 | 0 | 5·5 | 0 | 5 |

VO = Wheat grains treated with "Morkit" conc. (VO 4279)
T = Wheat grains treated only with talc
U = Wheat grains not denaturated

grains. In consequence of this a further test was carried out with this particular sparrow using a triple dosage of 300 g/50 kg. It was not until this dosage was applied that sparrow No. 11 reacted in the same manner as the other sparrows did at a dosage of 200 g/50 kg. The test showed that there were great differences in taste among the individual sparrows so that it is only by carrying out tests with a large number of birds of the same species that satisfactory results can be obtained. Similar experience was gained by T h i e m and S y (1943) with greenfinches *(Carduelis chloris)* which also revealed large individual differences in digestibility trials with repellents. "Morkit" conc. proved to be very superior to "Morkit" (cf. Table 4). In these tests hardly any treated wheat grains were consumed even at a dosage of only 100 g 50 kg.

*Group 3 (cf. Tables 5—7)*

The purpose of the third test group was to establish how the sparrows react when they are immediately given heavily denaturated wheat grains (300 g/50 kg) in addition to untreated wheat grains. The untreated wheat grains were also coated with talc in order to produce the same colour on all grains. The sparrows ate hardly any of the denaturated grains but here, too, there were individual differences. The most interesting fact is that sparrow No. 2 ate 2·5 g of wheat grains heavily dosed with "Morkit" even on the second day. Another purpose of this test was to answer the question as to the likelihood of the birds having become trained in the preceding tests. In my opinion the result clearly shows that the birds did not become trained and that the preparation had a strong effect.

S p e y e r (1954), too, obtained similar results in the tests he conducted on finches. In the dishes containing wheat grains treated with standard "Morkit",

| Sparrow No. | 1st day | | 2nd day | |
|---|---|---|---|---|
| | M | T | M | T |
| 2 | 1 | 5 | 2·5 | 4 |
| 3 | 0 | 6·5 | 0 | 6·5 |
| 4 | 0 | 7 | 0·5 | 6·5 |
| 5 | 0·5 | 7 | 0·5 | 7 |
| Total | 1·5 | 25·5 | 3·5 | 24 |
| Average value | 0·5 | 6·5 | 1 | 6 |

*Table 5:*
Consumed quantity of wheat grains expressed in grammes.
M = Treated with "Morkit" (300 g/50 kg)
T = Grains treated only with talc

37 % of the grains were left unconsumed while in the dishes containing grains treated with concentrated "Morkit" 52 % were not eaten. Only 3·5 % of the wheat grains were left unconsumed in the check dishes.

The tests described above will serve to strengthen the optimistic opinion that under favourable weather conditions there are very good prospects of keeping house sparrows away from cultures which have to be protected, by applying "Morkit" preparations. As the dusts, however, are very quickly washed off by rain, it is commendable to use "Morkit" Spray which has a far better adhesive property, in order to protect emerged plants, buds, harvest crops etc. "Morkit" Spray is applied at a concentration of 1 to 2 %. Many tests have been carried out with this spray, and have produced good results. E. Schneider of Eutin was very successful in preventing bullfinches *(Pyrrhula pyrrhula)* from feeding on buds. He was also successful in protecting ripe red currants

| Sparrow No. | 1st day | | 2nd day | |
|---|---|---|---|---|
| | VO | T | VO | T |
| 1 | 0 | 6 | 0 | 6 |
| 6 | 0 | 6·5 | 0·5 | 3·5 |
| 7 | 0 | 5·5 | 0·5 | 5 |
| Total | 0 | 18 | 1 | 14·5 |
| Average value | 0 | 6 | 0·5 | 5 |

*Table 6:*
Consumed quantity of wheat grains expressed in grammes.
VO = Treated with "Morkit" conc. (VO 4279) (300 g/50 kg)
T = Grains treated only with talc

*Table 7:* Average quantity of grains expressed in grammes consumed by one sparrow in one day.

| "Morkit" | Talc | "Morkit" conc. (VO 4279) | Talc |
|---|---|---|---|
| 1 | 6·5 | 0·5 | 5·5 |

against starlings *(Sturnus vulgaris),* and wheat already stacked in sheaves against sparrows by using this preparation which had been placed at his disposal for test purposes. It has been found that there is no danger of health hazards arising out of the consumption of crops treated with "Morkit" preparations.

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# Bees and Systemic Insecticides


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The investigations into the influence exerted by chemical pesticides on bees started several years ago by the branch office of the Växtskydd Station in Linköping, have in the main been devoted partly to the pyrenone preparations (cf. Växtskyddsnotiser No. 1, 1953) and partly to systemic insecticides In No. 2 of Nordisk Bitidskrift, 1953, a report is given on the results obtained with "OMPA" and "Systox" in laboratory tests. Reference is also made to several field tests which, however, due to a number of unfortunate circumstances could not be carried out in 1952. It was, therefore, all the more im-

portant to carry out field tests in 1953, and a report is given below on their outcome.

In Denmark, P. Johnsen discovered that "OMPA", when applied at blossom time, poisons bees which eat the nectar of plants treated with this spray. It is also immaterial whether the flowers are directly wetted or not by the spray. Symptoms of poisoning were estabilished even eleven days after the treatment. From his tests, which were reported in "Bee World 1953", it is evident that the nectar excreted from the treated plants is toxic, in fact for a considerable time after the spray. As "OMPA" has given only very few satisfactory results in pest control work carried out in Sweden, little importance has been attached to the question of the influence exerted by this preparation on beneficial insects in field tests.

The laboratory tests carried out earlier showed a relatively high degree of toxicity to bees. On the other hand, such good results had been obtained with "Systox", another rather toxic systemic preparation, that permission was given to apply it also in field crops visited by bumble-bees and bees. For this reason, field tests were run with "Systox" in the 1953 season. It must be made clear from the outset that in the laboratory tests "Systox" was found to have a toxicity to bees which is far greater than that of any other type of preparation tested to date, thiophosphorous preparations included. Plots of rapeseed were treated with "Systox" at blossom time (Fig. 1), at concentrations of 0·025 and 0·05 %. One treatment was carried out on May 19 in a rape stock where the blossom had just started. Following this, a large number of bees (five from each test plot) were collected which had visited the blossom (May 23, 26 and 29, June 5). These were placed together with a number of check bees, taken from another section of the same plots, in small cages located in the thermostat at a temperature of 30 ° C. They were fed as usual with Goods fodder and water. The number of dead bees was counted daily

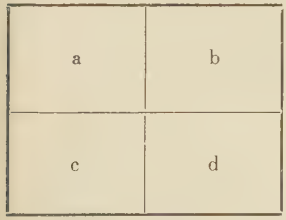


Fig. 1: Tests with "Systox" in rapeseed 1953: Treatment carried out on May 19.
a) treated from above, conc. 0·05 %
b) treated from below, conc. 0·05 %
c) treated from above, conc. 0·025 %
d) treated from below, conc. 0·025 %

No deviations in mortality were established among the collected bees. Those which visited the treated plants lived just as long, on the average, as the check bees. This applies to both test series, i. e. to those tests in which the lower parts of the plants were sprayed, and also to those in which the flowers and buds were wetted.

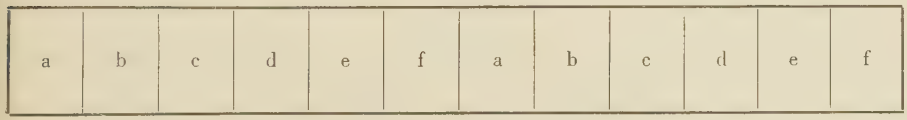


Fig. 2: Test with "Systox" on white mustard 1953, conc. 0·05 %.
a) untreated
b) plants sprayed on May 23
c) plants sprayed on May 23 and June 5
d) plants sprayed on May 23 and June 5
e) plants sprayed on June 5 and 12
f) plants sprayed on June 12

In another test also carried out on white mustard (Fig. 2), several plants were treated no less than three times during vegetation. The first spray was applied one week after germination, and the following sprays during the period up to bud formation. The plants were treated with 0·05 % "Systox". The method was, on the whole, more or less the same as that employed in the rape test. The result coincided with that obtained in the test on white mustard. Although no less than three treatments were carried out on the same plants, no toxic effect was detected on the bees collected for the purpose. A final check was made 14 days following the last treatment.

P. Johnsen reported recently in No. 33 of "Dansk Landbrug", 1953, that on examining the nectar of Fuchsia plants treated with "Systox" he found that it contained no poison, and therefore could not be harmful to bees. Great importance must be attached to the tests he carried out, which were run more on a laboratory scale, since a relatively large number of bees were fed with nectar taken from the treated plants. Johnsen's result can now be fully confirmed by the field tests reported here, which were carried out on rape and white mustard, two plants which contain abundant quantities of nectar. It can be said that "Systox" in the concentrations quoted here is harmless to beneficial insects when applied to blossoming seeds. For practical plant protection work in these crops, this means that oil plants, for example, can be treated with "Systox" shortly before the blossom period to prevent yield losses being caused by animal pests, without involving any risks. Further tests with "Systox" will undoubtedly show whether we have found a preparation which, in addition to being fully effective against pests, can be applied without causing any danger to beneficial insects.

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# Observations on the Inactivation of "Systox" in Crassulaceae*

by Herta Swart-Füchtbauer

The excellent adaptibility of "Systox" (a diethyl thionophosphoric ester of β-oxyethyl thioethyl ether developed by Schrader) as a systemically effective insecticide is to be attributed not only to its favourable therapeutic index but also to the high degree of stability enjoyed by this compound in the plant. Studies by Bosse, Hofferbert and Orth, Unterstenhöfer and Zattler have proved that "Systox" remains insecticidally effective in the plant for a number of weeks.

This discovery was at first surprising since "Systox", according to the manufacturers, in contrast to "Folidol-E 605" which is unstable in the plant, is easily affected chemically and physically. This lability of the insecticide which generally is very stable in the plant led to the question being raised as to whether substances specific to the plant are actually capable of attacking the insecticide chemically. To clarify this question, a study was made of the inactivation of "Systox" by several plant species and their expressed juices.

* Submitted for print in August 1953.

## Method

Flies of a strain of *Drosophila melanogaster* *, which were bred in cream bottles (250 ccs) at 25° C, were used to determine the respective concentration of insecticide.

In order to be able to use all the insects both for subsequent broods and also for the test, the hatched insects were collected every two days and placed in the fresh vessels for 4 days to lay eggs before they were tested. On each occasion, approximately 20 flies had to be placed in an experimental vessel, this only being possible when they were deprived of sensitivity. The state of torpidity was best obtained by subjecting the flies to a short cold shock, which was done by placing them in flasks cooled to 5° C. Immediately afterwards the flies, in contrast to those rendered torpid by ether, became motile again when replaced in the experimental vessels.

Embryonic dishes (3 cm diameter, 0·7 cm deep) were used as experimental vessels to test the toxic effect. They were sealed by means of small, square glass plates. The curved depressions were lined with filter paper, about 3·5 cm in diameter, which contained the substance to be tested (Schleicher and Schüll: No. BF). During the experiment the dishes were placed upside down on a glass plate in a thermostat at a temperature of 28° C, so that with the aid of a mirror it was an easy matter to count the dead flies (see Fig. 1).

The exactitude of this method was sufficient for these investigations in which it was not essential to trace minute concentrations of poison. The average error was 5 to 10 % for a concentration of "Systox" amounting to 0·005 % and less. Comparisons were made of the times in which 100 % of the flies were constantly lying on their backs. It was possible to answer for the comparison of the $LT_{100}$ since it was a matter of establishing large differences (Unterstenhöfer$_2$). My own method enjoyed the following advantages over others **:

1. It can be employed with a minimum of space and material.
2. The evaporation in the small room is greatly restricted so that the papers remain moist during the period of the experiment.
3. The insects do not fly, and are constantly in contact with the substrate as a result of their efforts to move upwards (on the filter paper). The dead flies fall onto the sealing plate, and consequently they can be counted easily.

Apples (Rosaceae), potatoes and tobacco (Solanaceae), mangold (Chenopodiaceae), maize (Gramineae), beans (Papilionaceae), *Bryophyllum tubiflorum*, *Crassula arborescens* and *Aeonium Haworthii* (Crassulaceae) were used as test plants. The insecticidal efficacy of 1 to 2 triturated leaves of plants wetted with "Systox" was tested five times within 61 days.

In the test where expressed juices of plants were used, agaves (Amaryllidaceae), rape (Cruciferae), potato haulms, potato tubers and Crassulaceae were taken as starting material. The juices were most effective when they were obtained by triturating the leaves in mortar, and applied undiluted. "Systox" was added to the expressed juices and the water checks, these being adjusted to the same pH values and checked at various intervals in the fly test for their concentration of insecticide.

* I would express my thanks to the Zoological Institute of the University of Bonn for providing me with the strain. Nutrient medium: 340 g water, 6 g agar, 50 g syrup, 50 g corn meal, 0·5 g Nipagin. Addition of filter paper and a few drops of a yeast suspension shortly before the insertion of the flies.

** Eichler, for example, used 200 cc glass cylinders (fixed) in his experiments with "DDT".

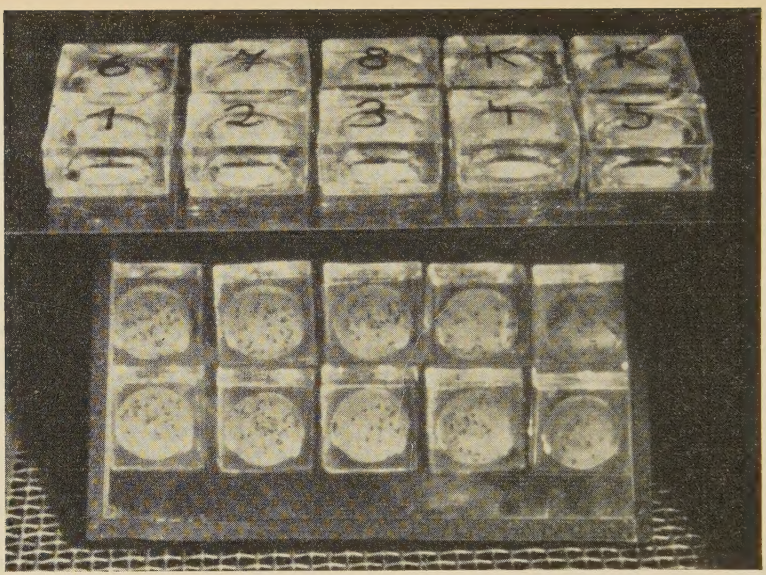

Fig. 1: "Systox" test with *Drosophila melanogaster*.

It was not necessary to add poisons to the expressed juices as a measure against microorganisms developing since extensive examinations of 22 strains of microorganisms had shown that "Systox" is not considerably affected by these strains. A sodium phosphate (sec.)-citric acid buffer, according to Ilvaine (cf. Kolthoff), was used for the standardization of different pH values.

## Results of experiment

The inactivation of "Systox" was tested on the afore-mentioned plants, three of each being wetted with 200 ccs of a 0·1 % emulsion of "Systox". Even in the first test, it was established that there was no insecticidally effective substance present in the Crassulaceae four days after the start of the test, whereas in all the other plants there were still traces of "Systox" after four weeks.

By wetting 3 *Aeonium Haworthii* plants each with 100 ccs of a 1 % "Systox" emulsion, it was possible to prove that the Crassulaceae actually do absorb "Systox". On the 1st and the 2nd day following the application of the insecticide, a slight effectiveness was established by means of the leaf test but on the 3rd day this was again negative. The slight and short-lasting trace of this concentration, which on other plants acts in a pathogenetic manner, led to the assumption that the absorption — conforming with the weak transpiration of the succulents — is admittedly only slight but that the insecticide is also rapidly inactivated by the plant's own substances.

In order to be able to trace this inactivation more exactly, "Systox", instead of being applied as a soil dressing to the living plants, and in accordance with the method employed by Frohberger with "Folidol-E 605", was added to the expressed juices of untreated plants. Whereas the juices of agaves, rape and potatoes hardly differed from the water checks in their reaction to the insecticide, and the "Systox" present in them remained effective for a long period, it was established beyond all doubt that "Systox" was inactivated by all the expressed juices of Crassulaceae tested. From the

graph it is seen that after being added to the expressed juice of the succulents (II), the inactivation of "Systox" commences immediately, and that after 13 days it is approximately 10 times that of the water check value (I).

The inactivating effect of the expressed juice of Crassulaceae can be determined both with "Systox" (=active ingredient + emulsifier) and with the pure active ingredient "E 1059". It is reduced accordingly by diluting the expressed

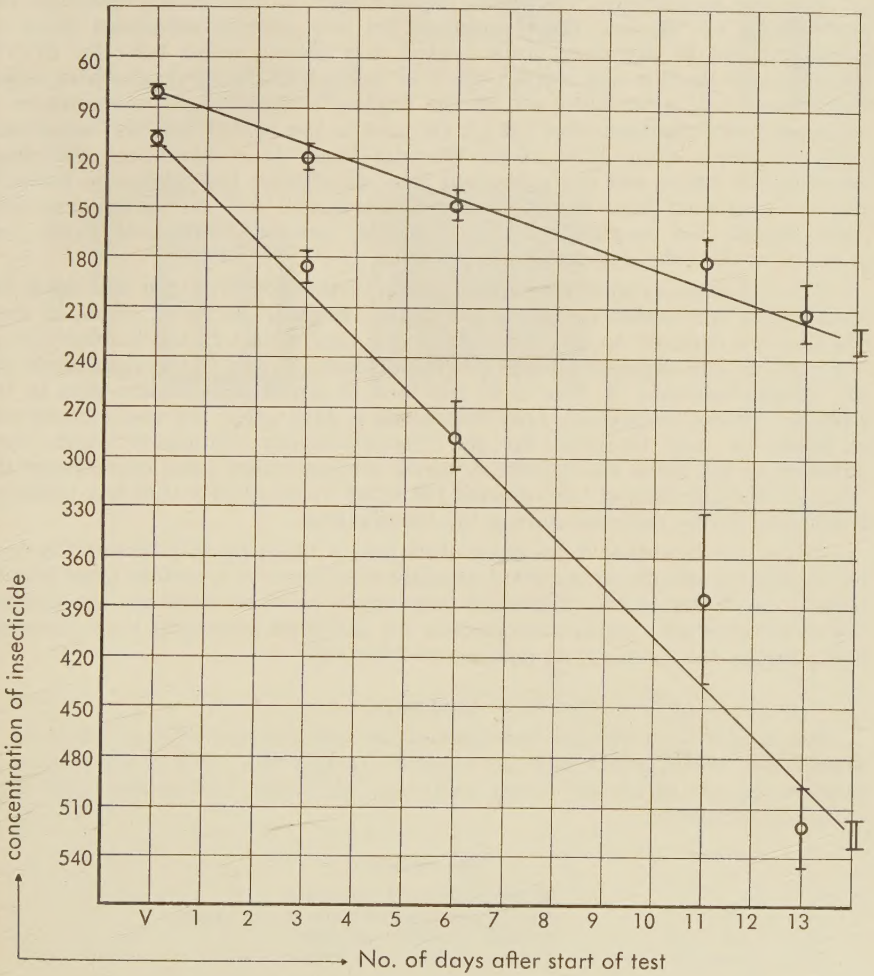


Fig. 2: Insecticidal efficacy of an emulsion of "Systox" (0·005%) in water (I) and in expressed juice of *Aeonium Haworthii* (II)
Ordinate: Time in which 100% of test flies were killed, expressed in minutes.
Abscissa: Number of days after the start of the test (V). The standard deviation of the mean

$$m = \pm \sqrt{\frac{\Sigma x^2 - M \cdot \Sigma x}{n\,(n-1)}}$$

is shown on both sides of each average value.

juice with water. The inactivation of "Systox" by the expressed juice of succulents is particularly impressive when it is considered that normally the insecticide is extremely stable at the pH value of 4·5 which the Crassulaceae have as based on their large share of malic acid and isocitric acid.

Further tests were carried out to establish the inactivating factor in expressed juice.

In order to examine whether a thermostable substance was involved, the inactivation of "Systox" was compared in the normal expressed juice of succulents and in expressed juice heated in a boiling water bath for 10′. On the same day the test was started, the flies in the 0·005 % "Systox"-water emulsions succumbed after 82·5 ± 4·3′, in the "Systox"-expressed juice emulsions of the same concentrations after 108·7 ± 4·0′, and in the heated "Systox"-expressed juice emulsions after 105·0 ± 0·0′. Whereas there is a significant difference between the water and the expressed juice emulsions, the difference between the two expressed juice values is only slight, a sign that the heated expressed juice, despite the coagulation of the protein, inactivates the insecticide just as much as does the normal expressed juice.

The influence exerted by various concentrations of hydrogen ions upon the inactivation was tested in order to ascertain whether enzymes, which in their reaction are confined to a certain pH range, play a part in the inactivation of "Systox" by the expressed juice of Crassulaceae. It was found that in all the pH ranges examined (4, 5, 6, 7, 8), the time of eradication for the flies in the 0·001 % "Systox"-expressed juice emulsions 8 days after the test started was at least 1·6 that recorded for the "Systox"-water emlusions which were adjusted to the same concentration. Since the expressed juice decomposes the "Systox" independent of the adjusted pH value, it is unlikely that any influence is exerted by the enzymes during the inactivation.

It can be concluded from these tests that a rapid inactivation of "Systox" by substances specific to the plant actually does occur in a certain plant family, namely the Crassulaceae. Therefore, allowances must be made for the possibility of other plants, which economically are far more important than Crassulaceae, having the property to decompose "Systox".

## Summary

By means of a simple test method, it was established that "Systox" is inactivated within a few days in various Crassulaceae. This is apparently an inactivation not restricted to any particular pH range, and caused by a thermostable substance.

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